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Cutsforth

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(54) **BRUSH HOLDER ASSEMBLY WITH QUICK DISCONNECT TERMINAL**

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(51) **Int. Cl.**

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H01R 39/36	(2006.01)
H02K 13/00	(2006.01)
H02K 11/00	(2016.01)

(52) **U.S. Cl.**

CPC ***H01R 39/383*** (2013.01); *Y02E 10/725* (2013.01)

(58) **Field of Classification Search**

CPC H01R 39/383; H02K 13/00; Y02E 10/725
USPC 310/71, 242, 245, 249, 239, 240, 241; 439/28, 29, 212, 345, 342, 865, 888
See application file for complete search history.

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Primary Examiner — Minh Nguyen

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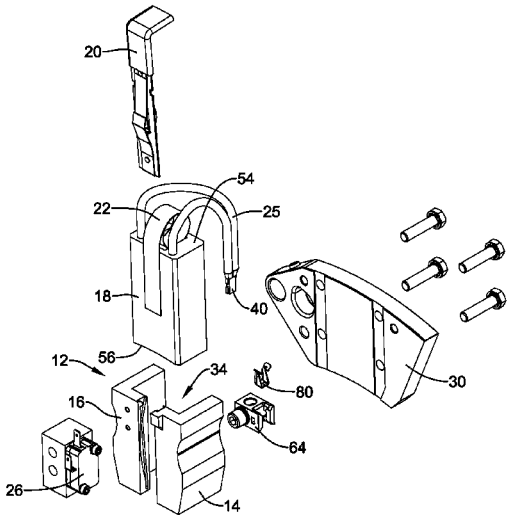
(57) **ABSTRACT**

A brush holder assembly including a quick disconnect assembly for quickly disconnecting a brush and electrical leads from a remaining component of the brush holder assembly to facilitate brush removal and replacement. The quick disconnect assembly includes a receptacle having a cavity for removably receiving and an end of the electrical lead, such as the nugget, and a resilient clip. When positioned in the cavity of the receptacle, the resilient clip urges a surface of the nugget into direct contact with a surface of the receptacle partially defining the cavity, completing an electrical current pathway from the brush through the electrical lead to the nugget, and from the surface of the nugget to the surface of the receptacle.

39 Claims, 30 Drawing Sheets



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Documents depicting various processes of electropolishing, sent by applicant on Dec. 17, 2002 (3pgs.).

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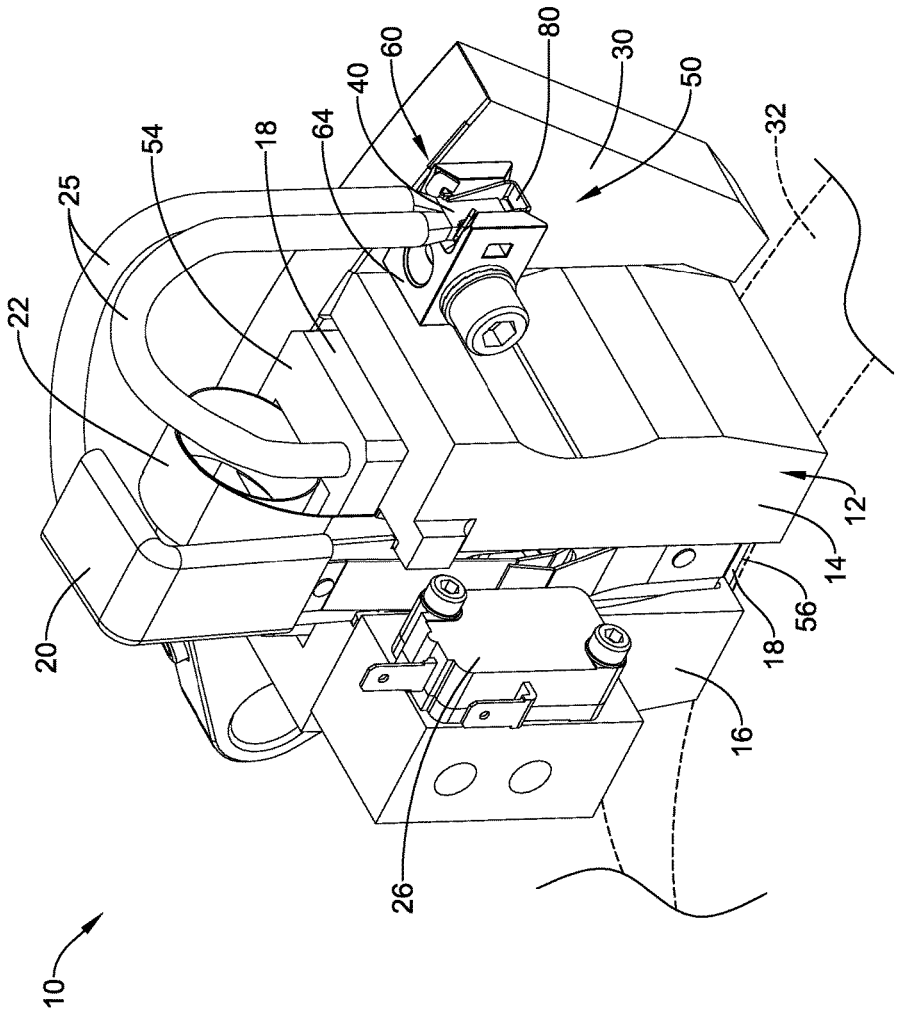

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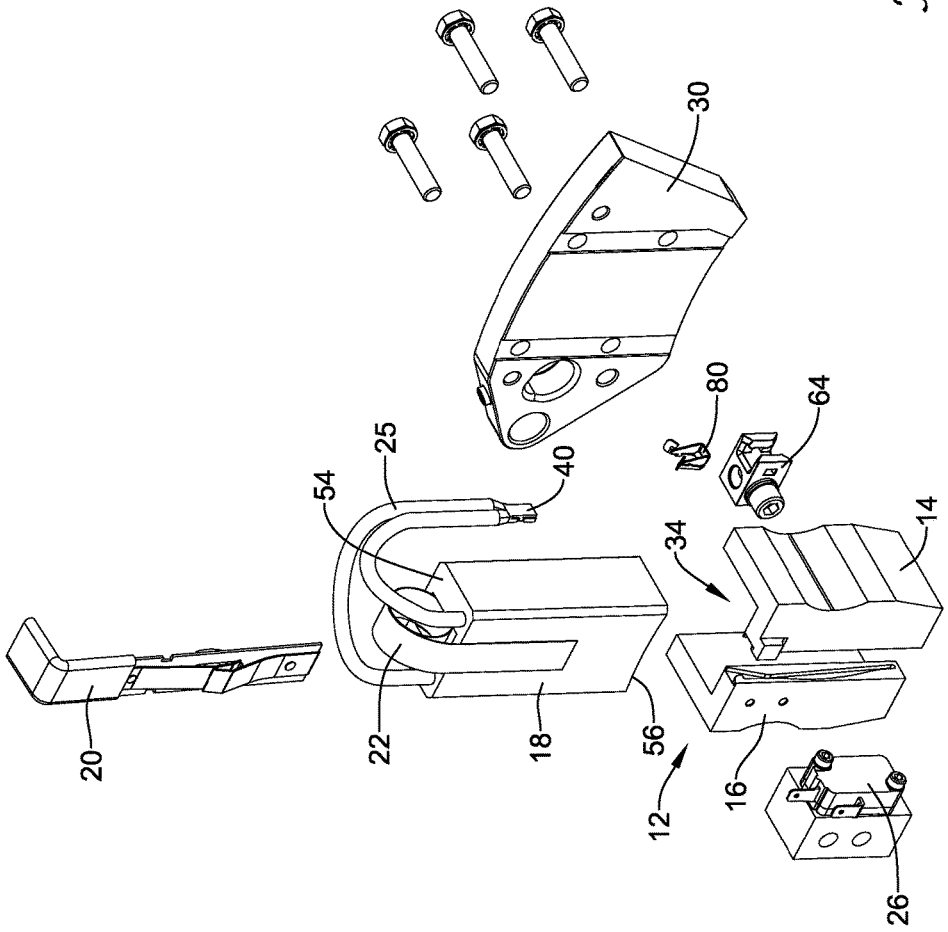

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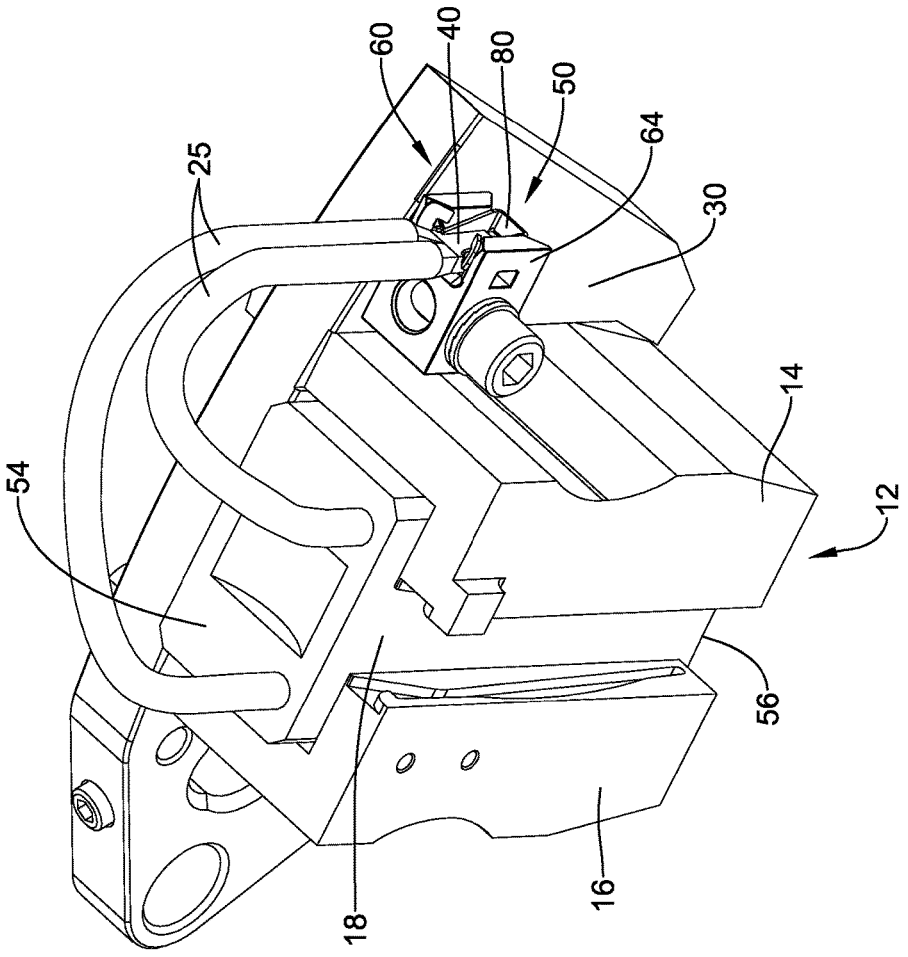

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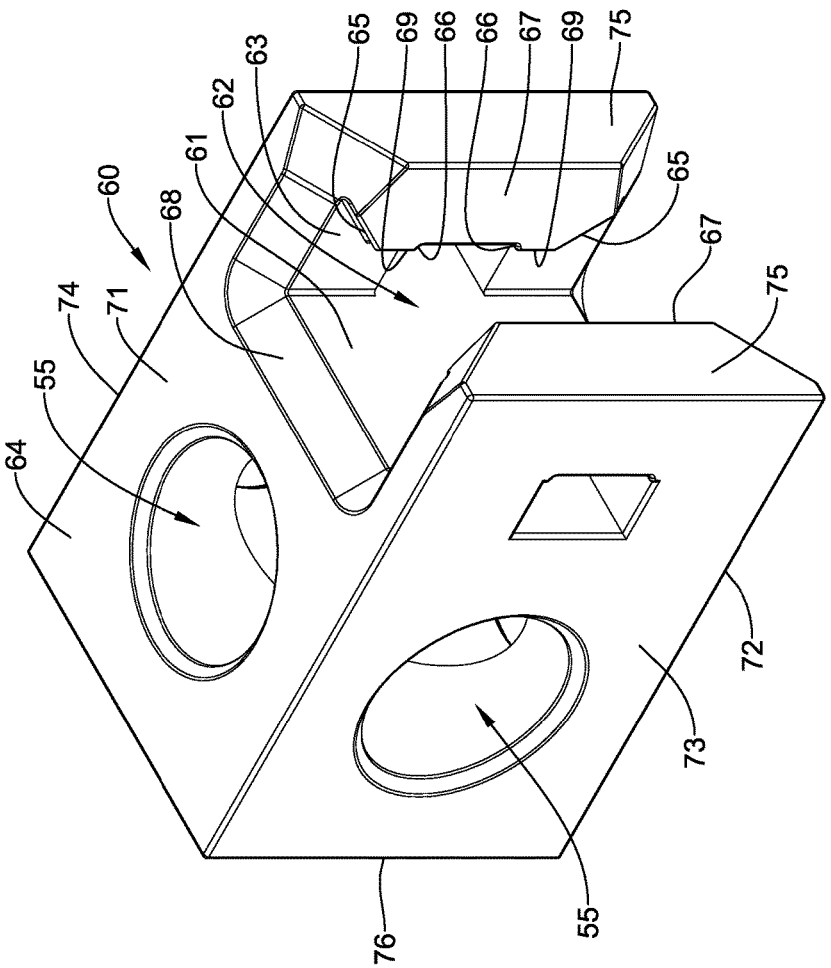

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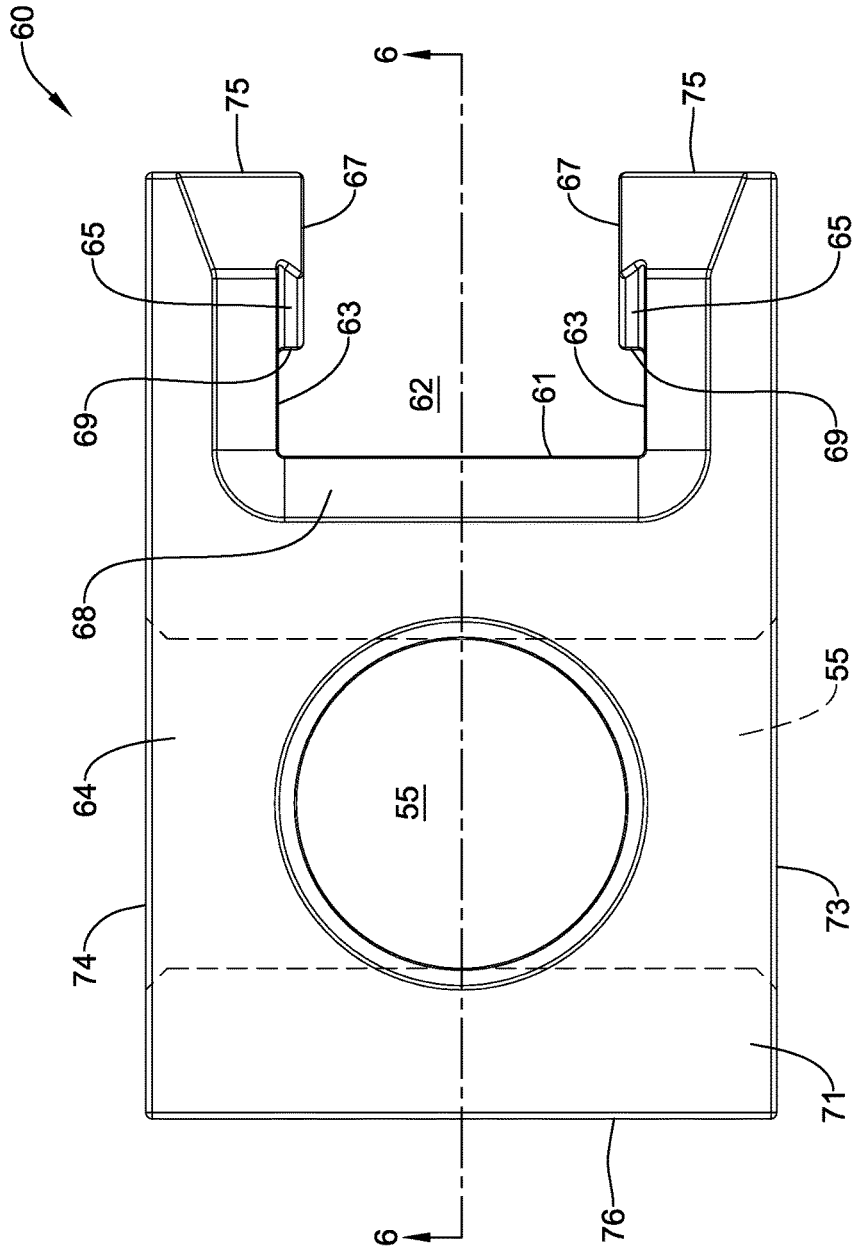

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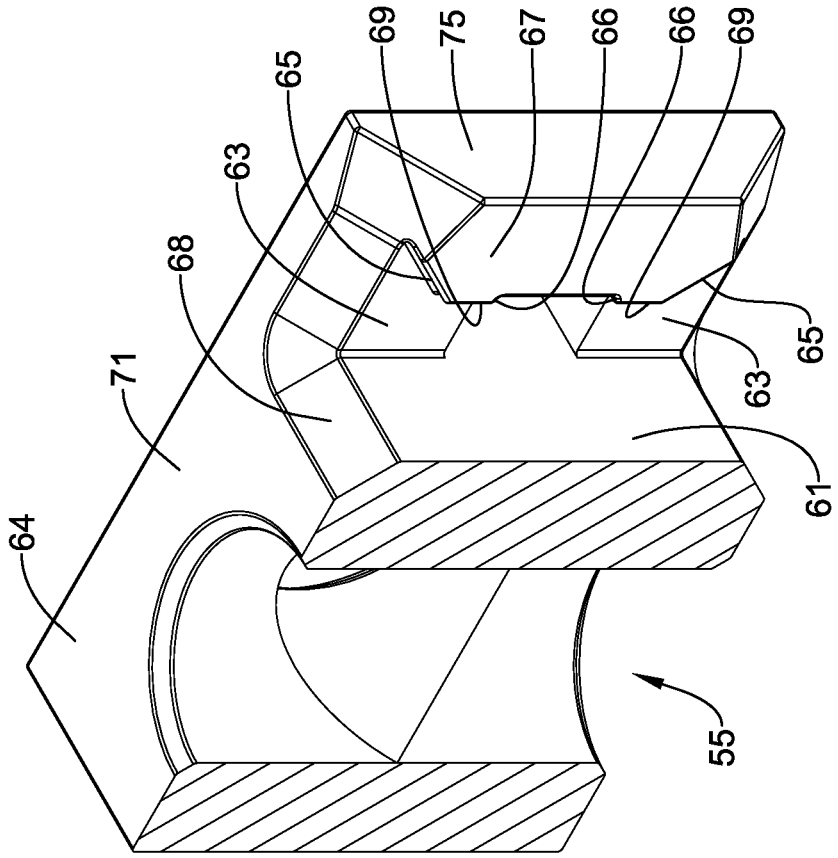

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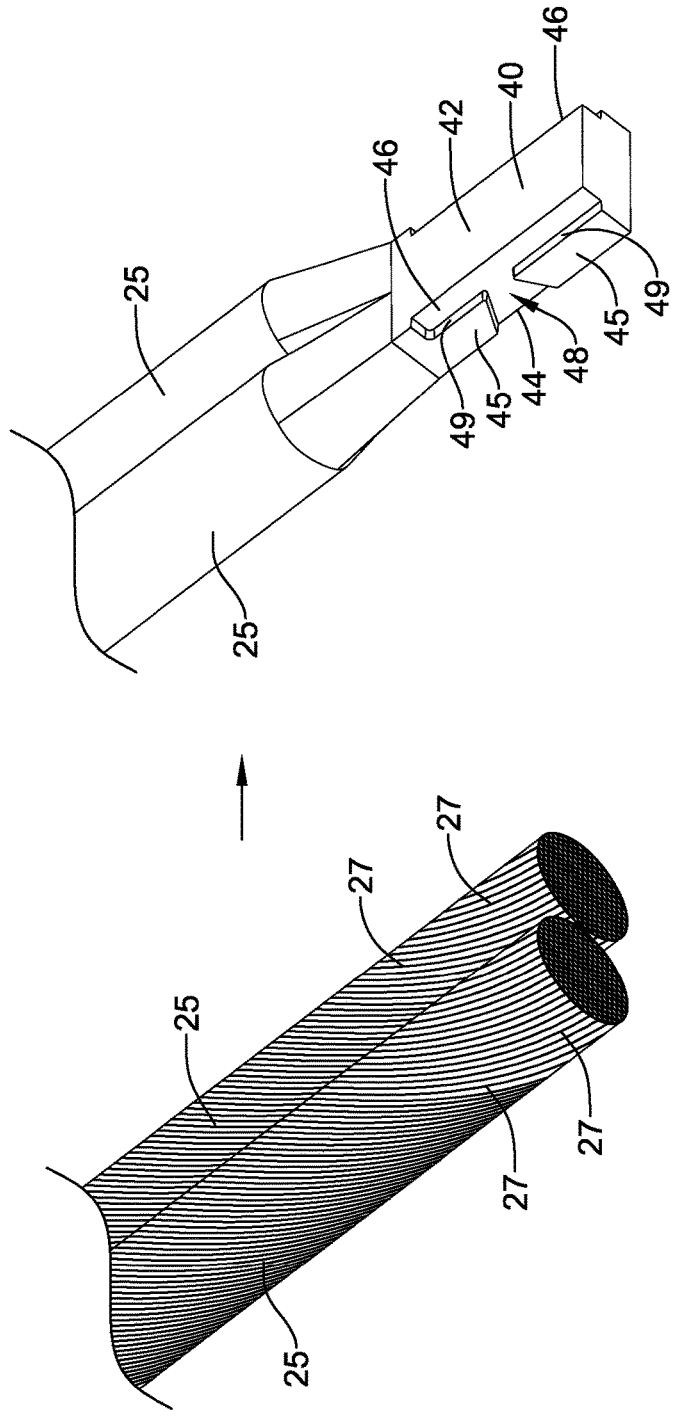

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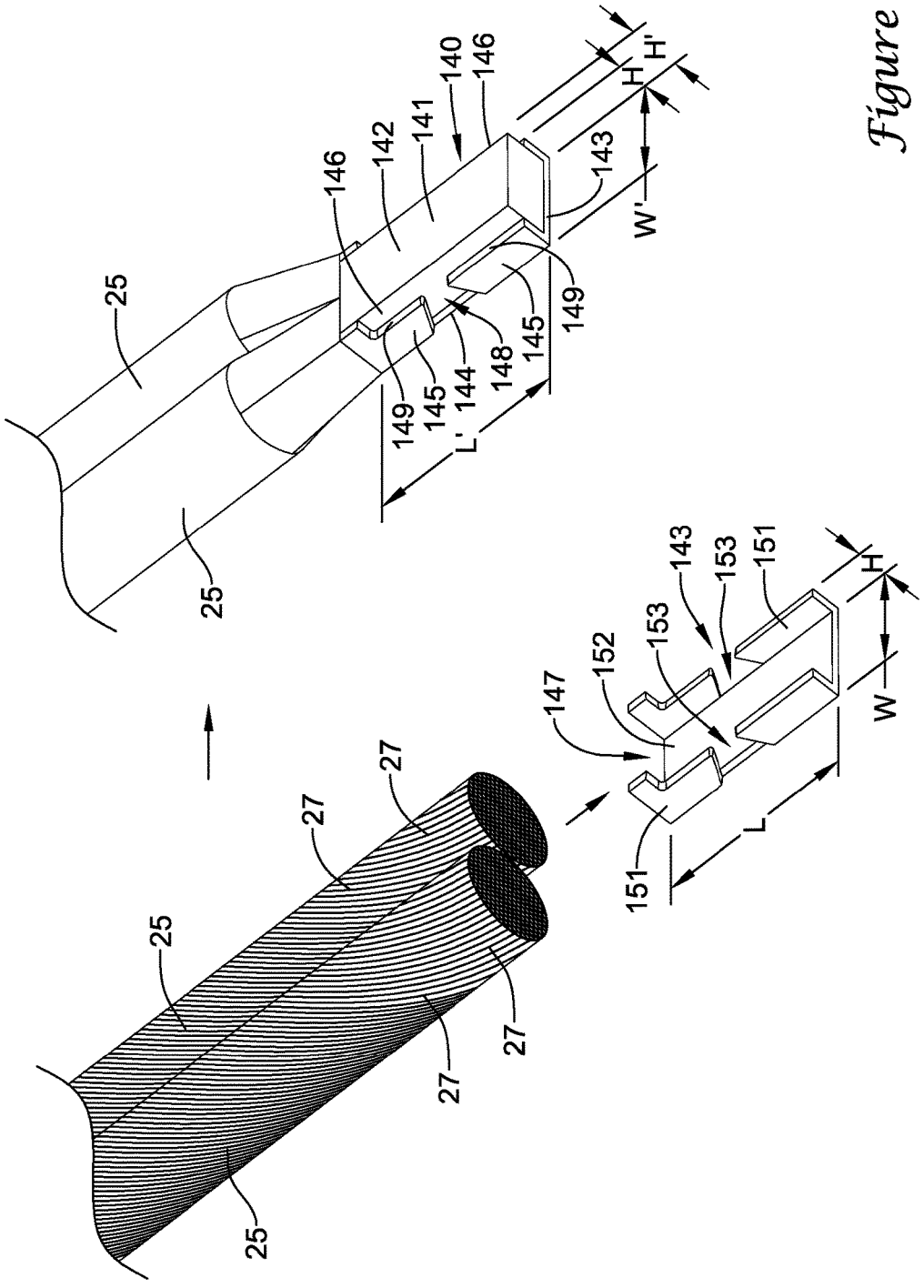
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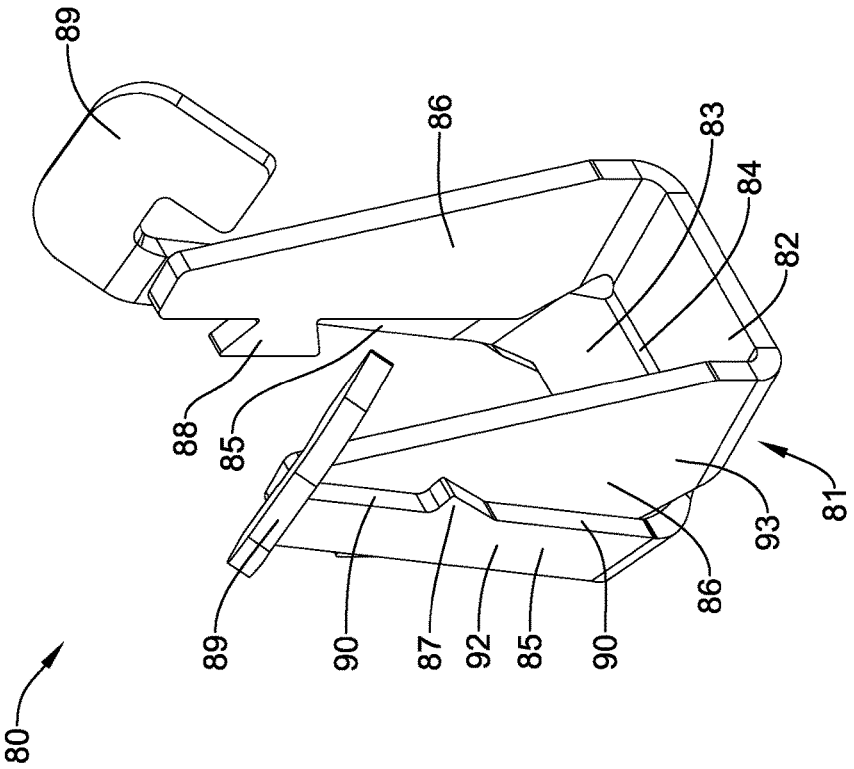

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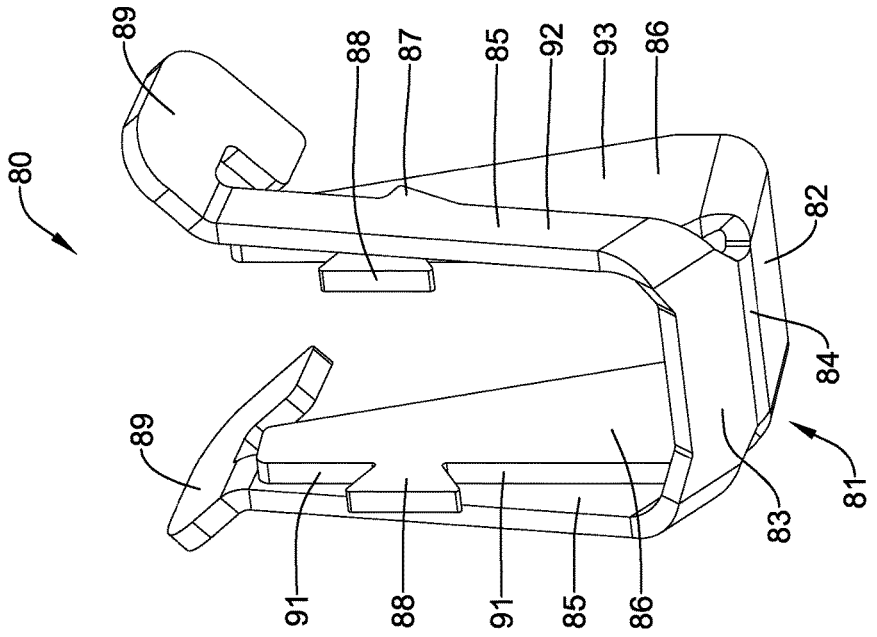

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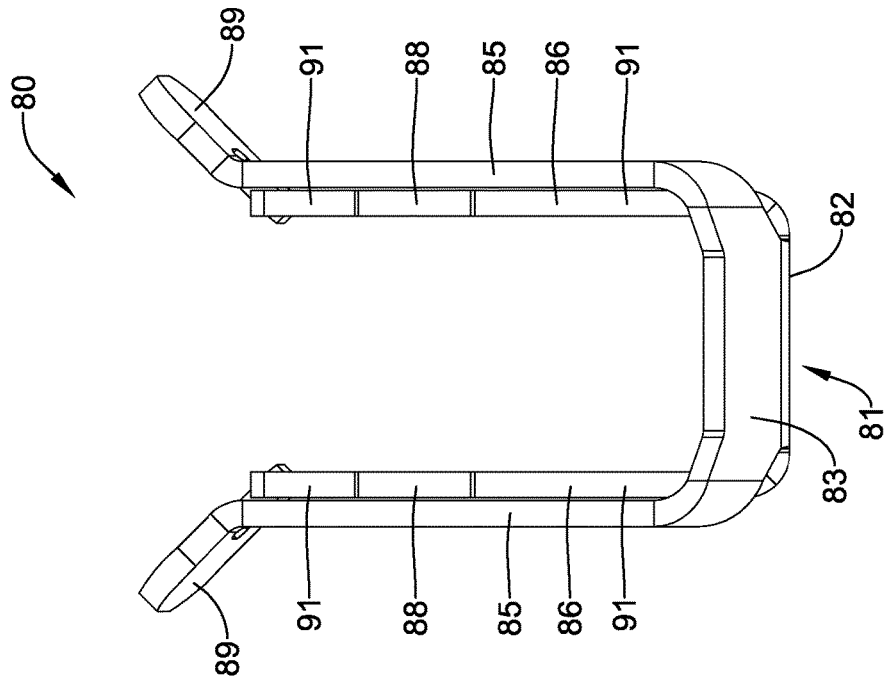

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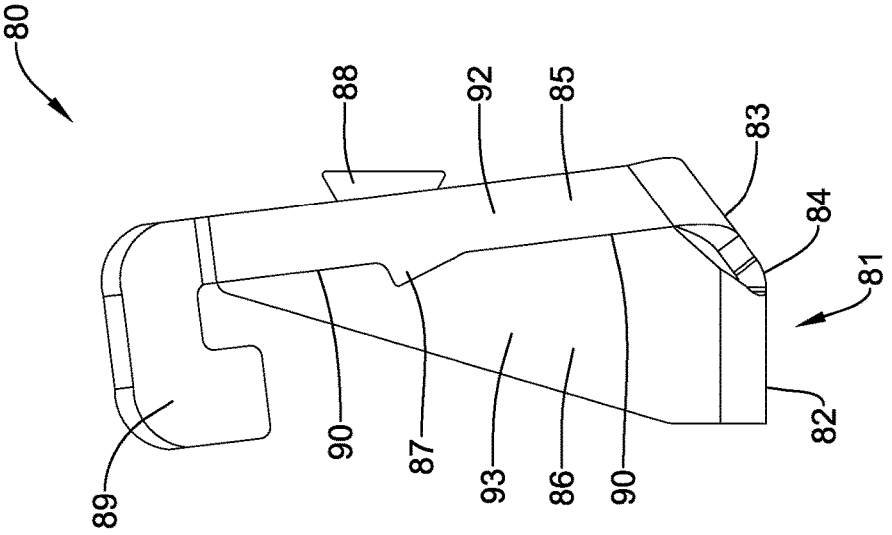

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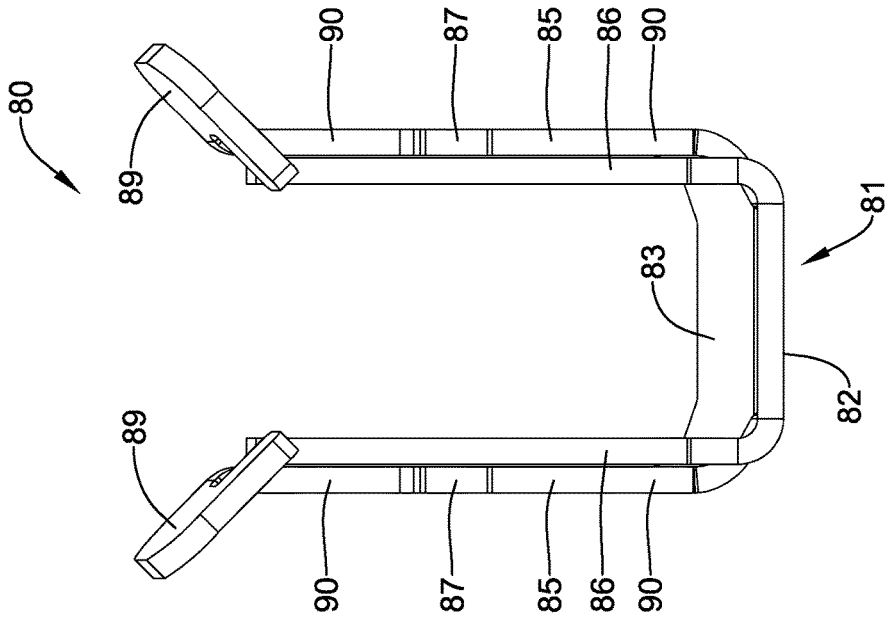

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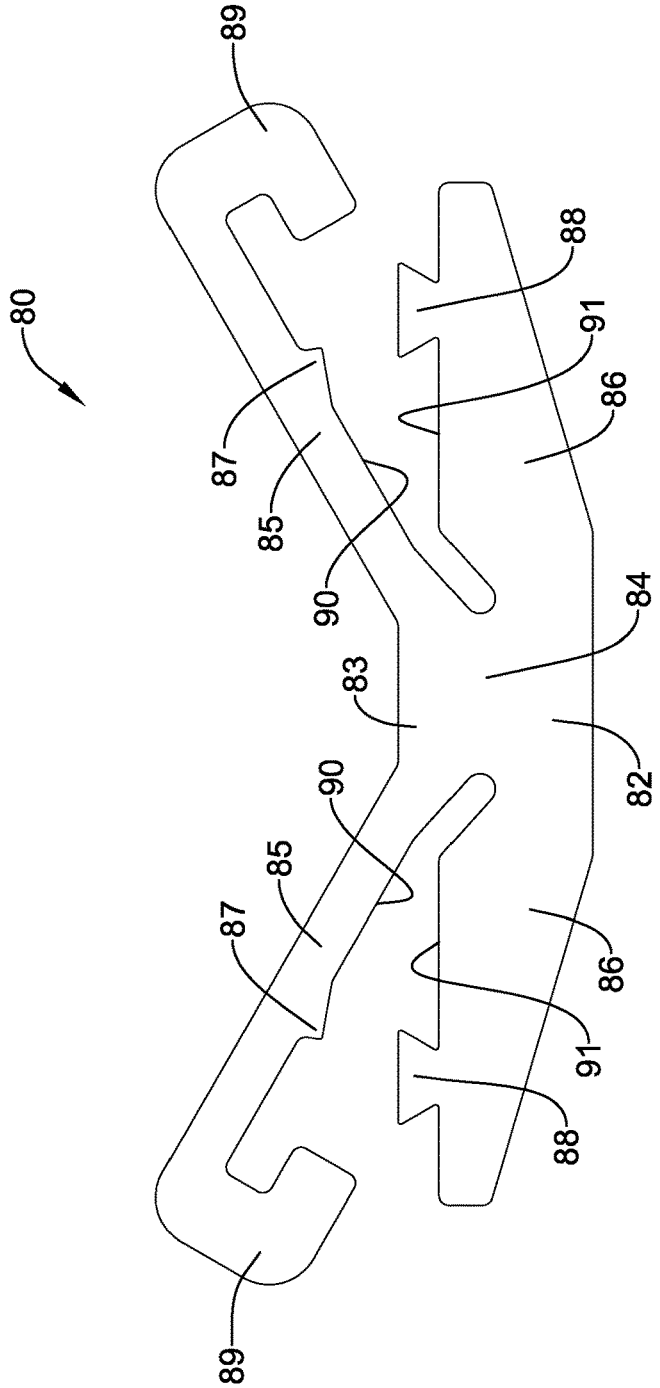

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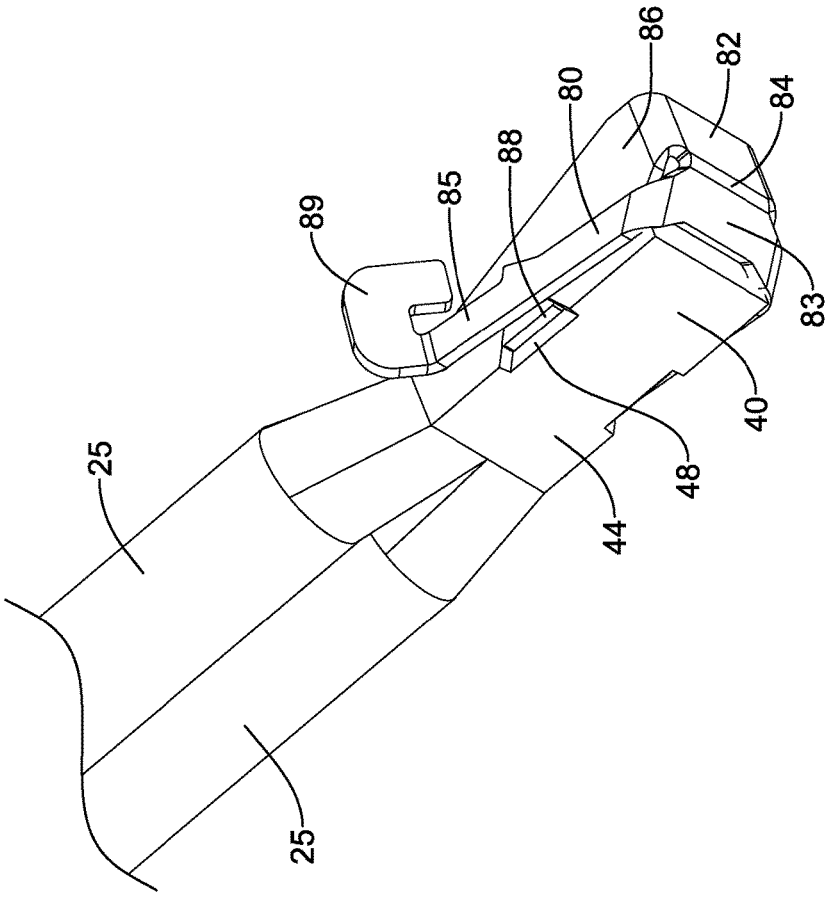

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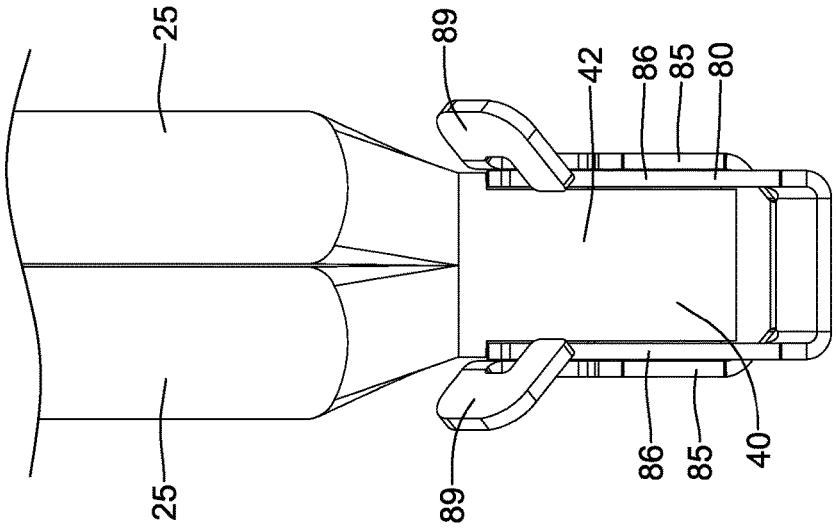

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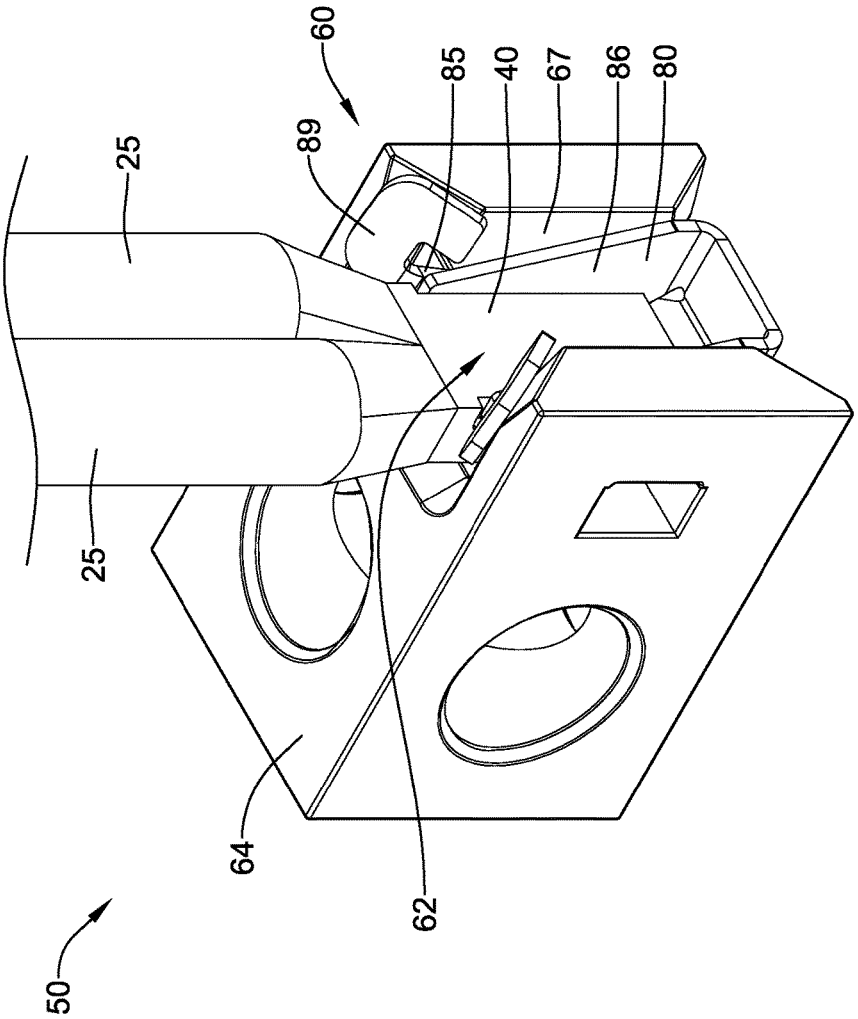

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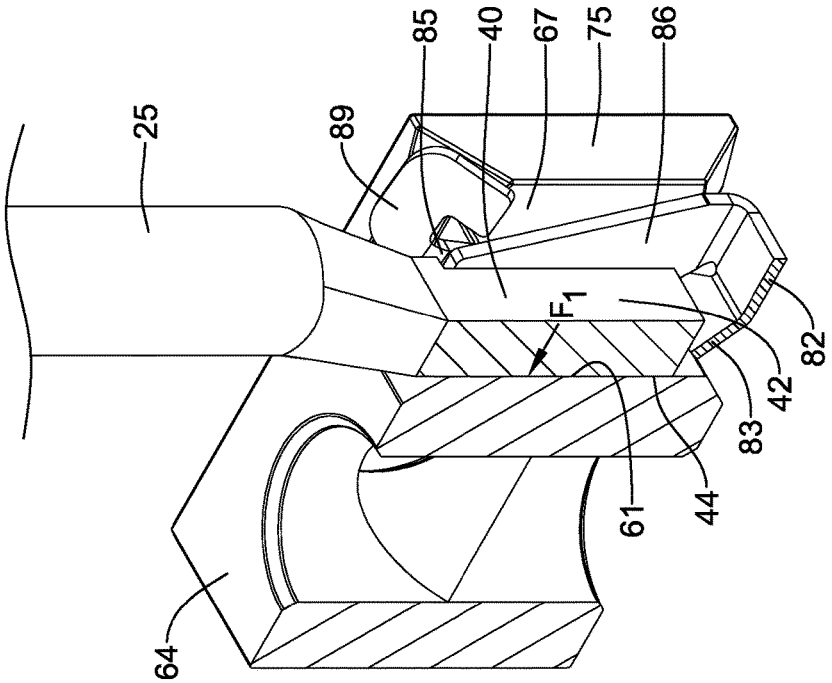

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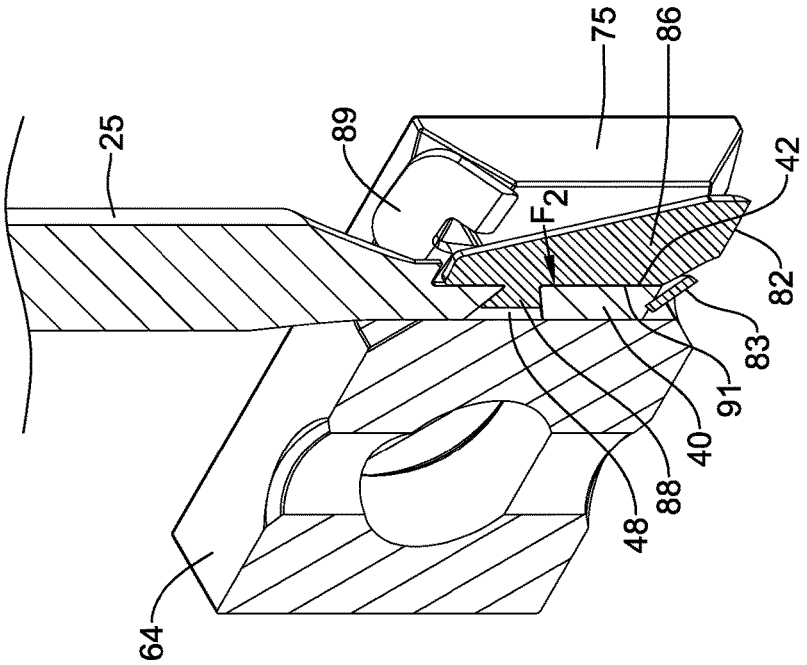

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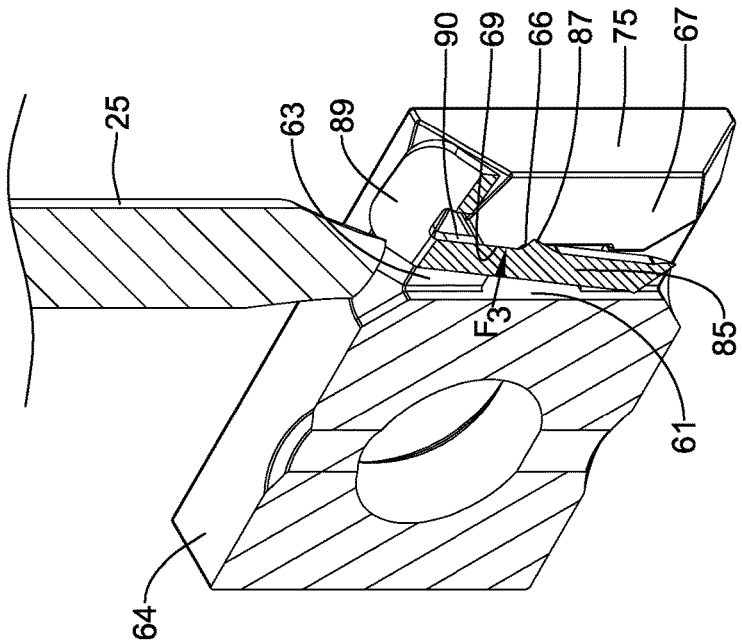

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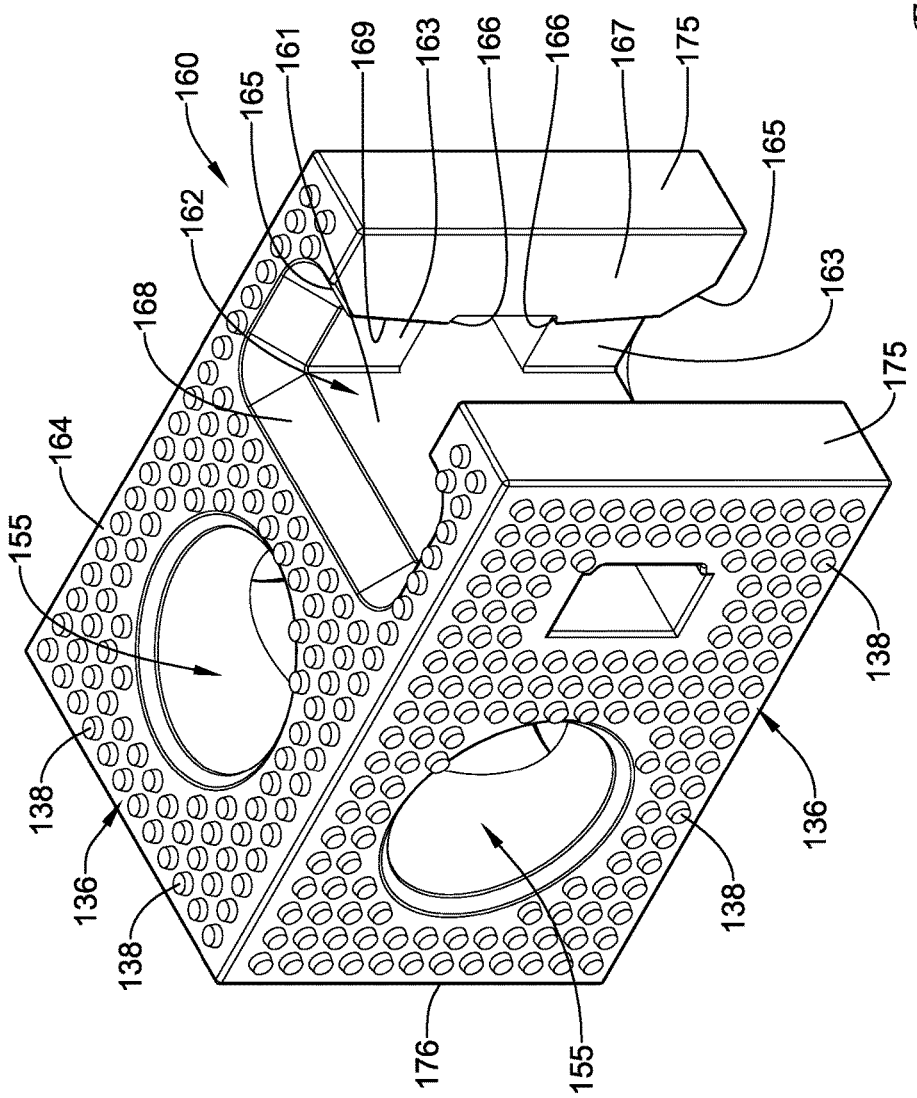
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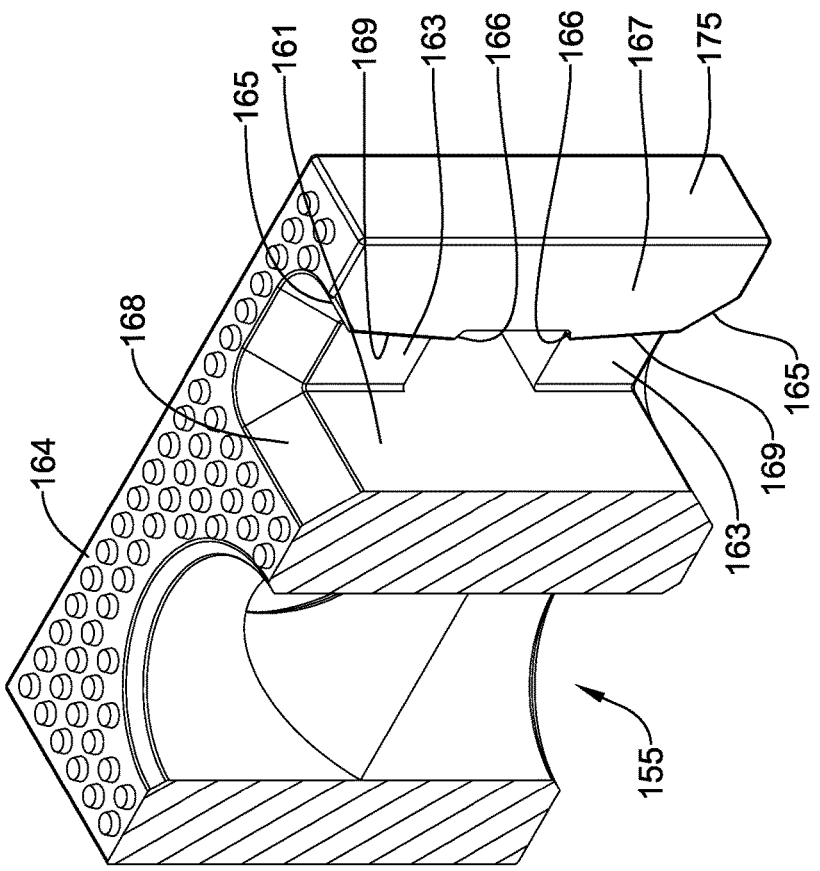

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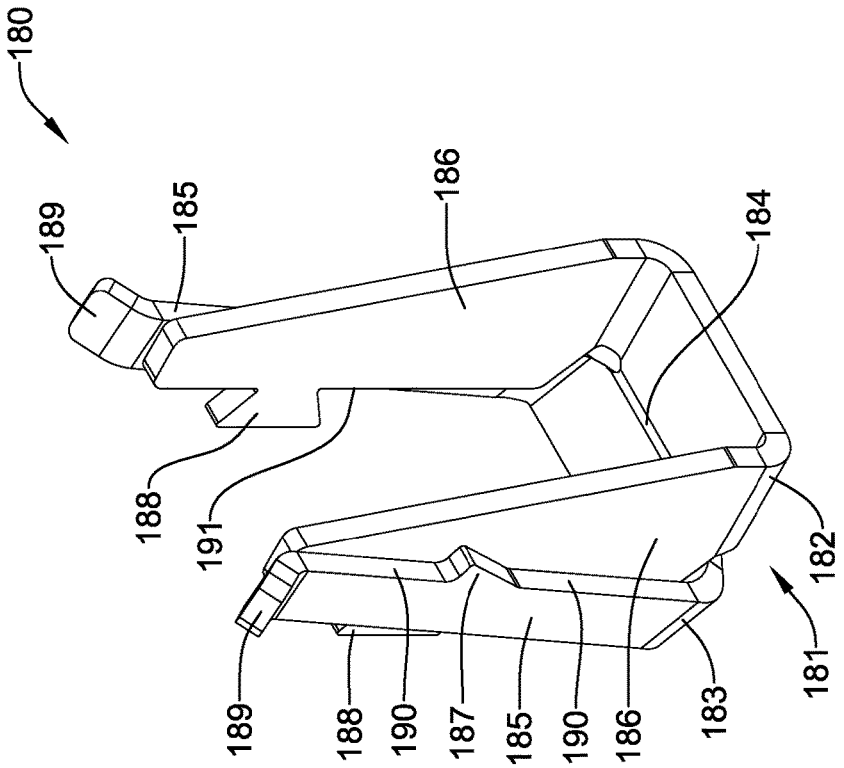
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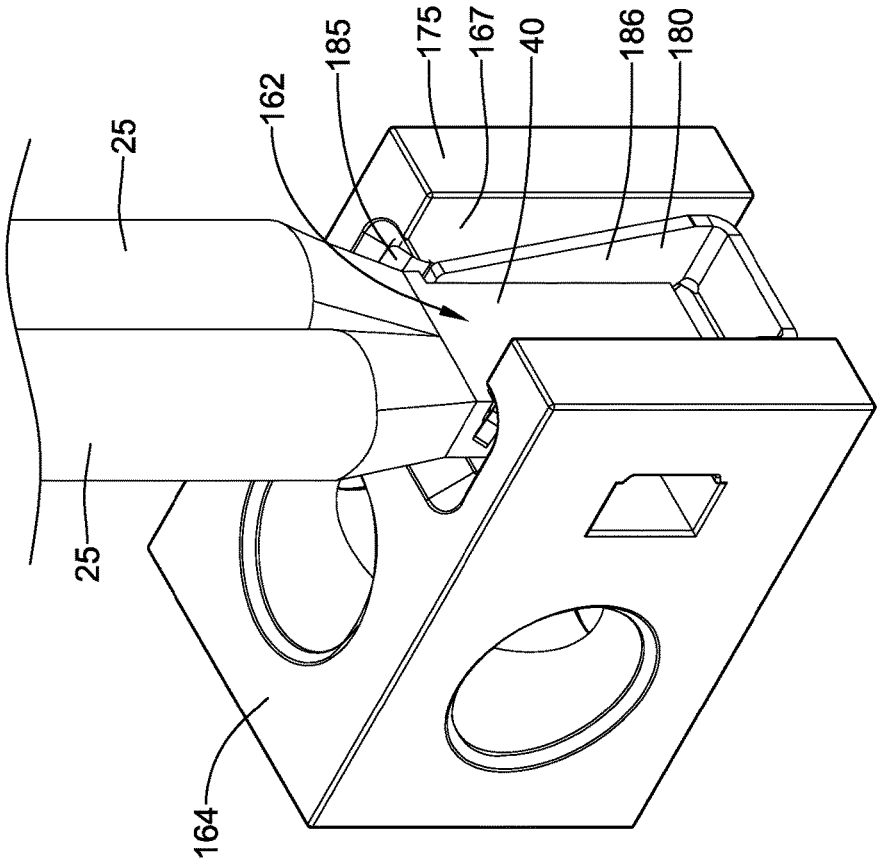

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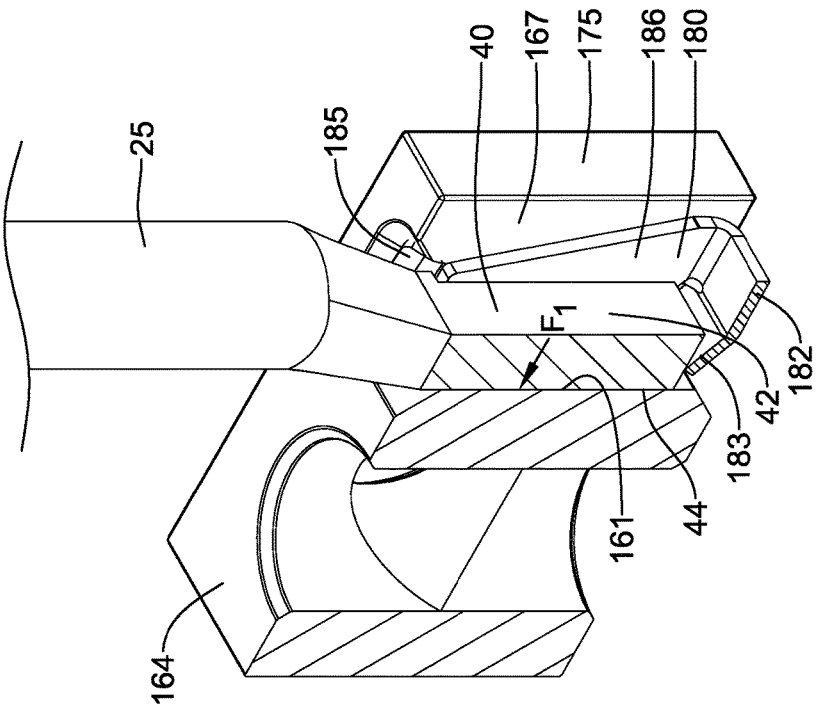

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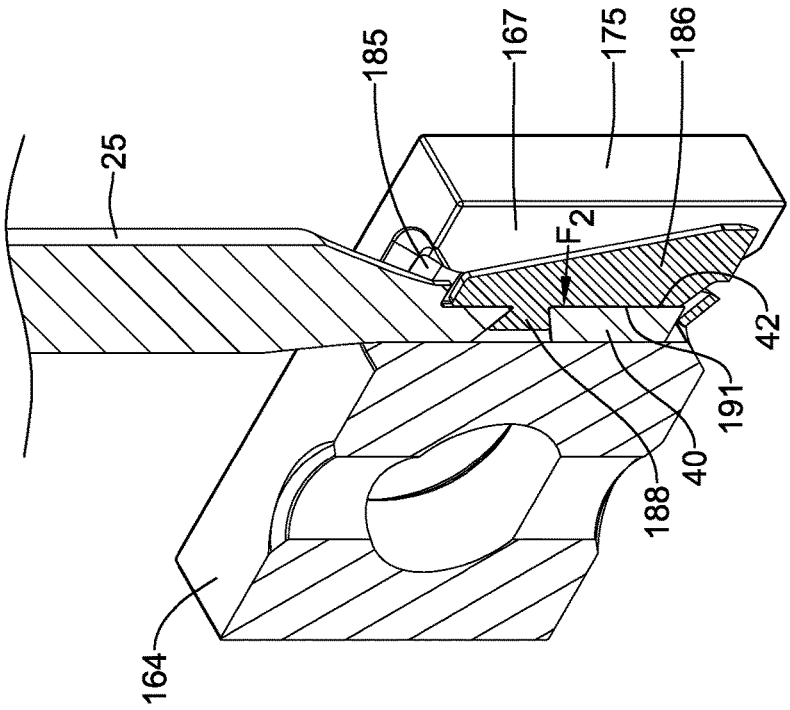

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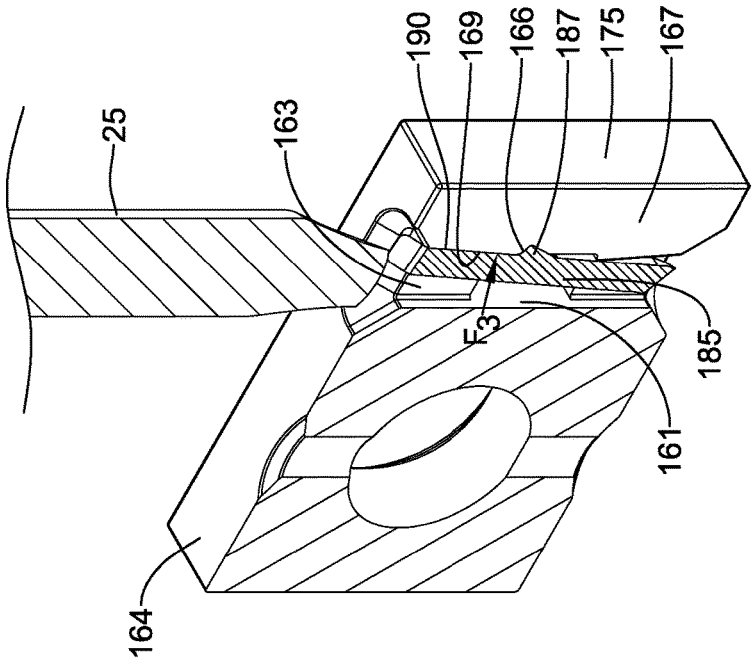

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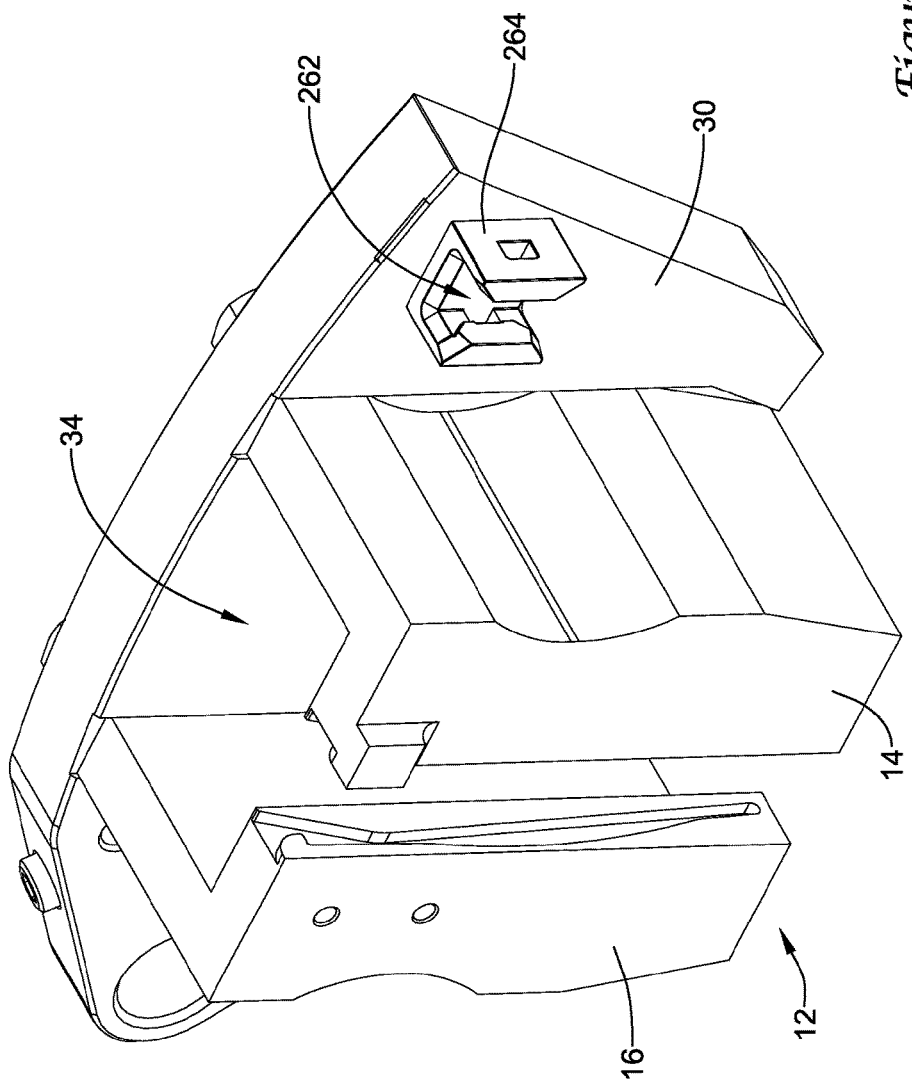

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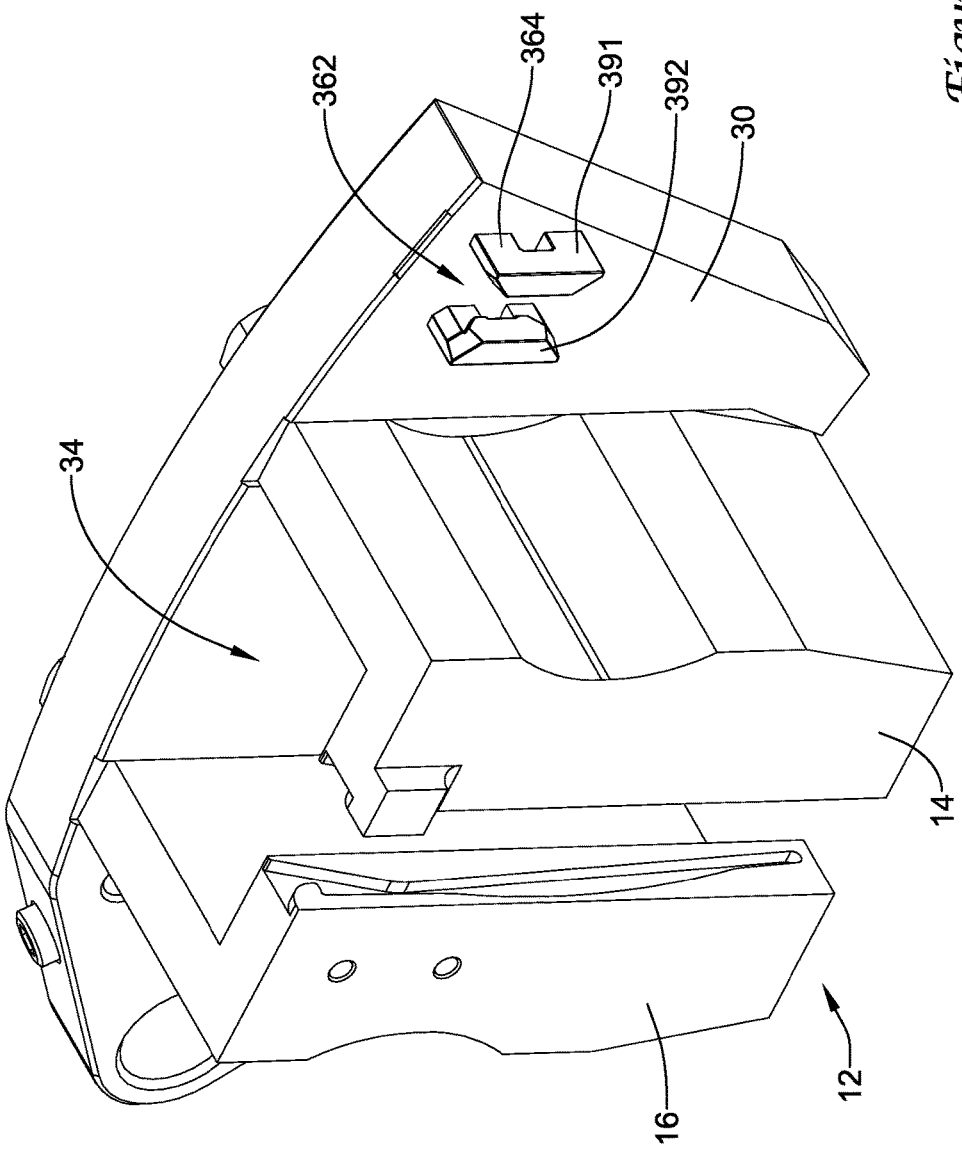

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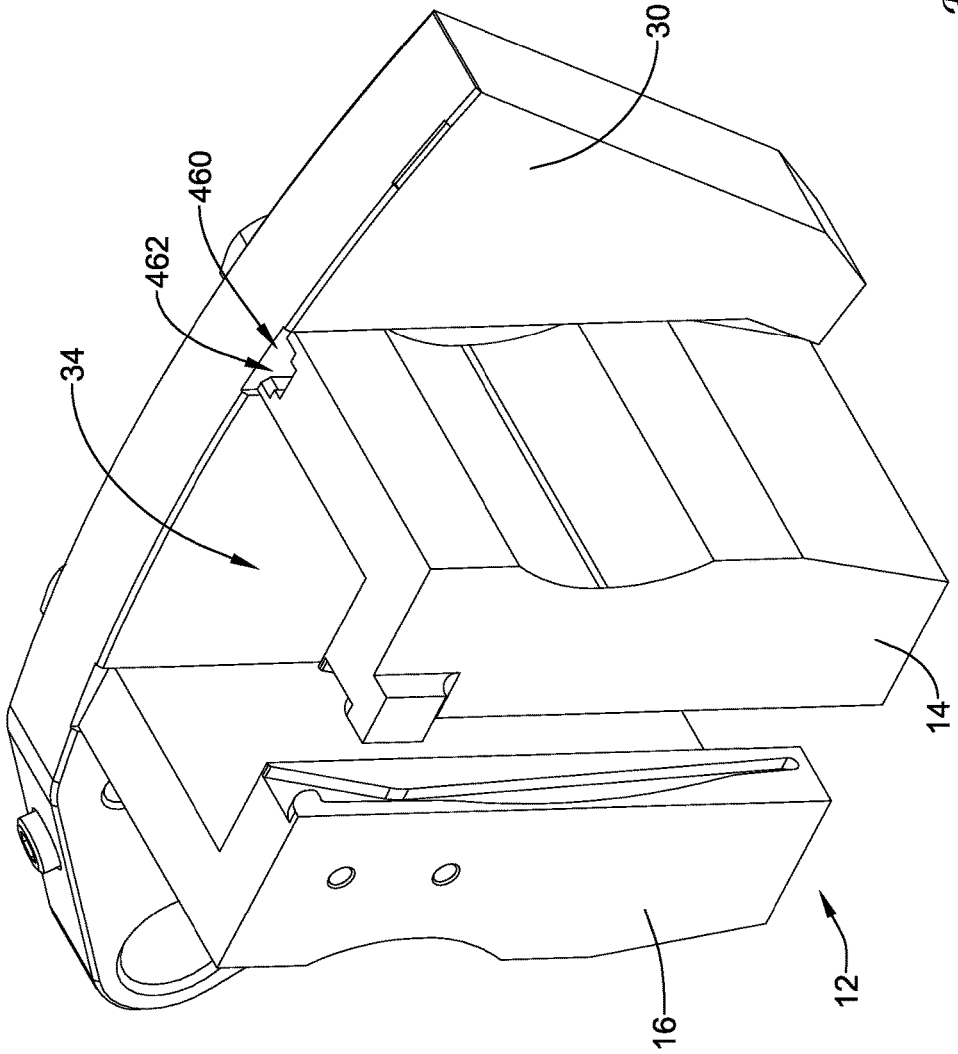

Figure 29

BRUSH HOLDER ASSEMBLY WITH QUICK DISCONNECT TERMINAL

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

TECHNICAL FIELD

The disclosure is directed to a brush holder assembly with a quick disconnect terminal for decoupling an electrical connection for a brush. More particularly, the disclosure is directed to a quick disconnect assembly for removably coupling a brush into electrical contact with a component of a brush holder assembly. In some instances, the quick disconnect assembly may be used in a variety of other electrical applications for quickly disconnecting an electrical connection.

BACKGROUND

A purpose of a brush in an electrical device is to pass electrical current from a stationary contact to a moving contact surface, or vice versa. Brushes and brush holders may be used in electrical devices such as electrical generators, electrical motors, and/or slip ring assemblies, or sliding connection applications, for example, slip ring assemblies on a rotating machine such as a rotating crane, a wind turbine or a linear sliding connection on a monorail. Brushes in many electrical devices are blocks or other structures made of conductive material, such as graphite, carbon graphite, electrographite, metal graphite, or the like, that are adapted for contact with a conductive surface or surfaces to pass electrical current.

In some designs, a box type brush holder is used to support the brush during operation. The brush and box are designed such that the brush can slide within the box to provide for continuing contact between the brush and the conductive surface contacted by the brush. Typically a spring, such as a constant force spring, presses against the upper surface of the brush to maintain contact between the lower surface of the brush and the conductive surface.

During the duration of operation of the electrical device, the brush will be reduced in size, or get shorter (i.e., diminish in longitudinal length), for example, as the wear surface of the brush in frictional sliding contact with the conductive surface wears down. Once a brush has worn beyond a threshold amount, the brush and/or other components may need to be replaced and/or maintenance may need to be performed.

Accordingly, there is a desire to provide alternative ways in which a brush may be quickly and efficiently disconnected from an electrical current pathway in order to facilitate removal and replacement of brushes from an electrical device, such as an electrical generator.

SUMMARY

The disclosure is directed to several alternative designs, materials and methods of manufacture and use of brush holder structures and assemblies and electrical connections in brush holder assemblies.

Accordingly, one illustrative embodiment is a brush holder assembly including a brush holder mounted to a stationary member and a brush slidably disposed in the brush holder. The assembly further includes an electrical lead having a first end secured to the brush and a second end, with a resilient clip removably coupled to the second end of the electrical lead. Additionally, the brush holder assembly includes a receptacle for removably receiving the second end of the electrical lead and the resilient clip therein. An electrical pathway is provided from the brush, through the electrical lead, to a surface of the receptacle.

Another illustrative embodiment is an assembly for providing an electrical current pathway through a brush holder assembly. The assembly includes a brush for contacting a moving conductive surface, an electrical lead extending from the brush having a first end secured to the brush and a nugget at the second end of the electrical lead, a resilient clip removably coupled to the nugget, and a receptacle having a cavity for removably receiving the nugget and the resilient clip therein. When positioned in the cavity of the receptacle, the resilient clip urges a surface of the nugget into direct contact with a surface of the receptacle partially defining the cavity, completing an electrical current pathway from the brush through the electrical lead to the nugget, and from the surface of the nugget to the surface of the receptacle.

Another illustrative embodiment is an assembly for providing an electrical current pathway through a brush holder assembly. The assembly includes a brush for contacting a moving conductive surface, an electrical lead having a first end secured to the brush and a second end. The assembly also includes a nugget at the second end of the electrical lead. The nugget includes a rear surface, a front surface opposite the rear surface, and first and second side surfaces extending between the front surface and the rear surface. A resilient clip is removably coupled to the nugget. The resilient clip contacts the front surface and faces the first and second side surfaces of the nugget. The assembly also includes a receptacle having a cavity for removably receiving the nugget and the resilient clip therein. The resilient clip is elastically compressed in the cavity to press against the nugget and urge the rear surface of the nugget into direct contact with a surface of the receptacle partially defining the cavity. An electrical current pathway is provided from the brush through the electrical lead to the nugget, and from the rear surface of the nugget to the surface of the receptacle.

Yet another illustrative embodiment is a method of replacing a brush in a brush holder of a brush holder assembly. The method includes removing a first brush from the brush holder by decoupling an end of a first electrical lead extending from the first brush along with a first resilient clip from a receptacle and then inserting a second brush into the brush holder. The second brush has a second electrical lead extending from the brush and a second resilient clip coupled to an end of the second electrical lead. The end of the second electrical lead and the second resilient clip are inserted into a cavity of the receptacle to provide an electrical pathway from the second brush, through the second electrical lead, to a surface of the receptacle.

The above summary of some example embodiments is not intended to describe each disclosed embodiment or every implementation of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be more completely understood in consideration of the following detailed description of various embodiments in connection with the accompanying drawings, in which:

FIG. **1** is a perspective view of an exemplary brush holder assembly;

FIG. **2** is an exploded view of components of the brush holder assembly of FIG. **1**;

FIG. **3** is a perspective view of components of an electrically conductive pathway of the brush holder assembly of FIG. **1** including a quick disconnect assembly, with some components of the brush holder assembly removed for clarity;

FIG. **4** is a perspective view of an exemplary receptacle of a quick disconnect assembly of the brush holder assembly of FIG. **1**;

FIG. **5** is a top view of the receptacle of FIG. **4**;

FIG. **6** is a cross-sectional view of the receptacle of FIG. **4**;

FIG. **7**A illustrates an exemplary method of forming a nugget on a pair of electrical leads;

FIG. **7**B illustrates another exemplary method of forming a nugget on a pair of electrical leads;

FIG. **8** is a perspective view from the front of an exemplary resilient clip of a quick disconnect assembly of the brush holder assembly of FIG. **1**;

FIG. **9** is another perspective view from the rear of the resilient clip of FIG. **8**;

FIG. **10** is a rear view of the resilient clip of FIG. **8**;

FIG. **11** is a side view of the resilient clip of FIG. **8**;

FIG. **12** is a front view of the resilient clip of FIG. **8**;

FIG. **13** illustrates the resilient clip of FIG. **8** prior to bending the resilient clip into its final shape;

FIG. **14** is a perspective view of the resilient clip coupled to the nugget of an electrical lead;

FIG. **15** is another perspective view of the resilient clip coupled to the nugget of an electrical lead;

FIG. **16** is a perspective view of the components of a quick disconnect assembly coupled together;

FIG. **17** is a cross-sectional view of the quick disconnect assembly of FIG. **16** taken along a first plane;

FIG. **18** is a cross-sectional view of the quick disconnect assembly of FIG. **16** taken along a second plane;

FIG. **19** is a cross-sectional view of the quick disconnect assembly of FIG. **16** taken along a third plane;

FIG. **20** is a perspective view of another exemplary receptacle of a quick disconnect assembly;

FIG. **21** is a cross-sectional view of the receptacle of FIG. **20**;

FIG. **22** is a perspective view from the front of an exemplary resilient clip of a quick disconnect assembly for use with the receptacle of FIG. **20**;

FIG. **23** is a perspective view of the components of a quick disconnect assembly shown in FIGS. **20** and **22** coupled together;

FIG. **24** is a cross-sectional view of the quick disconnect assembly of FIG. **23** taken along a first plane;

FIG. **25** is a cross-sectional view of the quick disconnect assembly of FIG. **23** taken along a second plane;

FIG. **26** is a cross-sectional view of the quick disconnect assembly of FIG. **23** taken along a third plane; and

FIGS. **27-29** illustrate alternative embodiments of a receptacle of a quick disconnect assembly of an electrical connection in a brush holder assembly.

While the invention is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the intention is not to limit aspects of the invention to the particular embodiments described. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention.

DETAILED DESCRIPTION

For the following defined terms, these definitions shall be applied, unless a different definition is given in the claims or elsewhere in this specification.

All numeric values are herein assumed to be modified by the term "about", whether or not explicitly indicated. The term "about" generally refers to a range of numbers that one of skill in the art would consider equivalent to the recited value (i.e., having the same function or result). In many instances, the term "about" may be indicative as including numbers that are rounded to the nearest significant figure.

The recitation of numerical ranges by endpoints includes all numbers within that range (e.g., 1 to 5 includes 1, 1.5, 2, 2.75, 3, 3.80, 4, and 5).

Although some suitable dimensions, ranges and/or values pertaining to various components, features and/or specifications are disclosed, one of skill in the art, incited by the present disclosure, would understand desired dimensions, ranges and/or values may deviate from those expressly disclosed.

As used in this specification and the appended claims, the singular forms "a", "an", and "the" include plural referents unless the content clearly dictates otherwise. As used in this specification and the appended claims, the term "or" is generally employed in its sense including "and/or" unless the content clearly dictates otherwise.

The following detailed description should be read with reference to the drawings in which similar elements in different drawings are numbered the same. The detailed description and the drawings, which are not necessarily to scale, depict illustrative embodiments and are not intended to limit the scope of the invention. The illustrative embodiments depicted are intended only as exemplary. Selected features of any illustrative embodiment may be incorporated into an additional embodiment unless clearly stated to the contrary.

Now referring to FIGS. **1** and **2**, an illustrative brush holder assembly **10** is shown. The brush holder assembly **10** is shown assembled in FIG. **1**, while FIG. **2** shows various components of the brush holder assembly **10** in an exploded view for illustrative purposes.

The brush holder assembly **10** may include a brush holder **12**, such as a brush box, surrounding a brush **18** on several sides and including a plurality of guiding surfaces for guiding linear or longitudinal movement of the brush **18** therein into contact with a moving surface of an electrical device. For instance, in some embodiments the brush holder assembly **10** may substantially resemble a brush holder assembly as described in U.S. Pat. No. 7,034,430, entitled "Brush Holder Apparatus, Brush Assembly, and Method", which is herein incorporated by reference in its entirety. However, in other embodiments, the brush holder assembly **10** may include a brush holder, such as one or more posts for guiding linear or longitudinal movement of a brush into contact with a moving surface of an electrical device.

In some embodiments, the brush holder assembly **10**, including the brush holder **12**, may be of similar construction to the brush holder assemblies and brush holders described in U.S. Pat. No. 7,880,362, which is herein incorporated by reference in its entirety. For instance, one side of the brush holder **12** may include a slot extending from the top of the brush holder **12** toward the bottom of the brush holder **12**. For example, the slot, which may be an

opening, may extend from the top surface of the brush holder **12** to the bottom surface of the brush holder **12**, dividing the brush holder **12** into two portions, a first portion **14** and a second portion **16**. The first portion **14** of the brush holder **12** may face the brush **18** on one or more, or a plurality of sides of the brush **18** and/or the second portion **16** of the brush holder **12** may face the brush **18** on one or more, or a plurality of additional sides of the brush **18**. As shown in FIGS. **1** and **2**, the first portion **14** is a separate component from the second portion **16**, together forming the brush holder **12**. However, in other embodiments, the first portion **14** and the second portion **16** may be two portions of a unitary structure forming the brush holder **12**. In some embodiments, the slot between the first portion **14** and the second portion **16** of the brush holder **12** may be a recess, depression, gap, space, opening or the like, of the brush holder **12**.

The brush holder **12** may be secured to a stationary structure, such as a base member or yoke **30** of the electrical device, a portion thereof which is shown in FIGS. **1** and **2**. In other embodiments, the stationary structure may be a stud, cross arm, adapter, or other member of the electrical device which remains stationary relative to the moving contact surface in sliding contact with the brush **18**. For example, in some embodiments, the brush holder **12** may be rigidly mounted to another structure holding the brush holder **12** stationary, or mounted to another structure in any desired arrangement. For instance, in some embodiments the brush holder **12** may be bolted or welded to the stationary structure, such as bolted or welded to the base member or yoke **30**. As shown in FIGS. **1** and **2**, each of the first portion **14** and the second portion **16** of the brush holder **12** may be bolted to the base member or yoke **30** with a plurality of bolts or other fasteners. Additional brush holders, such as a second, third, fourth, fifth and/or sixth brush holder similar to the brush holder **12** disclosed herein, may be secured to the stationary structure, such as the base member or yoke **30** as desired. For example, first, second, third, fourth, fifth and/or sixth brush holders may be secured to the base member or yoke **30** radially around the moving contact surface of the electrical device.

The first portion **14** of the brush holder **12** may be spaced from the second portion **16** of the brush holder **12** along one side of the brush holder **12** such that the slot, which may be an opening between the first portion **14** and the second portion **16**, is defined between an edge of the first portion **14** and an opposing edge of the second portion **16**. In some embodiments, the edge of the first portion **14** may be parallel with the edge of the second portion **16**.

Secured to the stationary structure, for example the base member or yoke **30**, the brush holder **12** defines an interior opening **34** for receiving a brush **18** therein. As shown in the figures, the interior opening **34** may be collectively defined by a surface of the stationary structure (e.g., the base member or yoke **30**), and interior surfaces of the first portion **14** and second portion **16** of the brush holder **12**. In other words, the surface of the stationary structure may face a first side surface of the brush **18**, while interior surfaces of the first portion **14** second portion **16** may face additional side surfaces of the brush **18**. It is to be noted, however, that in other embodiments a surface of a portion of the brush holder **12** placed adjacent the surface of the stationary structure may partially define the interior opening **34** in place of or in addition to the surface of the stationary structure.

The brush holder assembly **10** is configured to place the bottom surface **56** of the brush **18** in contact with a conductive surface **32**, such as a rotating surface of a collector ring, a slip ring, or a commutator, and conduct current therefrom. The brush **18** may be positioned in the interior opening **34** of the brush holder **12** and may extend from the lower edge of the brush holder **12** such that a wear surface of the brush **18** engages the conductive surface **32**.

The brush **18** may include one or more, or a plurality of electrical leads **25** secured to the brush **18** providing a conductive pathway to or from the brush **18** for the flow of electricity. The electrical leads **25** have a first end secured to the brush **18** and a second end. A nugget **40** or other connector piece, such as a male connector, may be located at the second end of the electrical leads **25**.

The brush holder assembly **10** may also include a brush wear indicator switch **26** configured to indicate when the brush **18** has worn beyond a threshold amount through frictional and electrical contact with the conductive surface **32**. The switch **26** may generate a signal which indicates to an operator, monitor or other personnel that a brush **18** and/or other components may need to be replaced and/or maintenance may need to be performed on the brush holder assembly **10**. The switch **26** may include one or more, or a plurality of electrical terminals providing an electrical pathway for carrying an electrical current to and/or from the switch **26**, to generate an electrical signal.

Also illustrated in FIGS. **1** and **2** is a brush spring **22**, such as a constant force spring, which provides tension to the brush **18** to bias the brush **18** toward and in contact with the conductive surface **32**. For instance, the coiled portion of the spring **22** may be in contact with the top surface **54** of the brush **18** and press against the top surface **54** of the brush **18**, while a longitudinally extending portion (e.g., elongated portion) of the spring **22** may extend along and/or contact a side surface of the brush **18**.

The spring **22** may be coupled to a spring clip **20**, which may be removable from the brush holder **12** of the brush holder assembly **10**. In some instances, the spring **22** may be removably coupled to the spring clip **20**, such that the spring **22** may be readily removed from the spring clip **20** and replaced with a new spring **22** as desired. For instance, it may be desirable to replace the spring **22** with a new spring **22** each time a new brush **18** is installed in the brush holder assembly **10**. In some embodiments, the spring **22** and the spring clip **20** may be configured such that replacement of the spring **22** may be performed without the need for additional tools and/or extensive time requirements. In some embodiments, the spring **22** may be removably coupled to the spring clip **20** without the use of a rivet, weld, solder or other similar fastening means. In some embodiments the spring **22** may be removed from the spring clip **20** without removing a bolt, screw of other threaded fastener. Thus, in some embodiments, the spring **22** may be slipped or slid on and off, or otherwise disconnected from the spring clip **20** without the need of removing a bolt, screw, rivet, weld, solder, or other fastening means. In other embodiments, the spring **22** may be coupled to the spring clip **20** with a rivet, weld, solder, bolt, screw or other fastening mechanism.

The spring clip **20** may be located between the first portion **14** and the second portion **16** of the brush holder **12** such that the spring clip **20** spans the slot between the edge of the first portion **14** and the edge of the second portion **16**. For example, opposing longitudinal edge portions of the spring clip **20** may be slidably disposed in opposing channels or grooves defined in the first and second portions **14**, **16** of the brush holder **12**.

The brush holder assembly **10** also includes a quick disconnect assembly **50** for quickly disconnecting the brush **18** and electrical leads **25** from a remaining component of

the brush holder assembly **10** to facilitate brush removal and replacement. For example, the quick disconnect assembly **50** may include a receptacle **60** having a cavity **62** for removably receiving and an end of the electrical lead **25**, such as the nugget **40**, and a resilient clip **80**. In some embodiments the receptacle **60** may be a body **64** having the cavity **62** formed therein, which may be a separate component bolted, or otherwise secured to either the stationary member or yoke **30** or the brush holder **12**, or other component of the brush holder assembly **10**. In other embodiments, the receptacle **60** may be integrally formed in either the stationary member or yoke **30** or the brush holder **12**, or other component of the brush holder assembly **10**. In other words, the stationary member or yoke **30** or the brush holder **12** may include the cavity **62** formed therein, for removably receiving an end of the electrical lead **25**, such as the nugget **40**, and the resilient clip **80**.

It is noted that although the quick disconnect assembly **50** is shown for use in an electrical connection of a brush holder assembly **10**, the quick disconnect assembly **50** may be used in a variety of other electrical applications for quickly disconnecting an electrical connection between a first electrically conductive member and a second electrically conductive member to disrupt an electrical pathway therebetween.

FIG. **3** illustrates an assembly of the brush holder assembly **10** for providing an electrical current pathway through the brush holder assembly **10** from the conductive surface **32** to the base member or yoke **30**. The quick disconnect assembly **50**, provided in the electrical current pathway, may facilitate replacing the brush **18** by providing an electrical connection between the electrical lead **25** coming from the brush **18** and a conductive surface (e.g., the base member or yoke **30**) in the electrical current pathway that may be selectively coupled and decoupled as desired.

The electrical current pathway may be provided from the conductive surface **32**, through the brush **18**, through the electrical lead **25** extending from the brush **18** to the nugget **40**, from a surface of the nugget **40** to a surface of the receptacle **60**, and from the receptacle **60** to a conductive member, such as the base member or yoke **30**.

One embodiment of the receptacle **60** may be further described with reference to FIGS. **4-6**. The receptacle **60** may be formed of a body **64**, such as a rigid metal block, having a first side **71**, a second side **72** opposite the first side **71**, a third side **73**, a fourth side **74** opposite the third side **73**, a first end **75** and a second end **76** opposite the first end **75**. The body **64**, in the form of a rigid metal block, may be an inert structure which does not flex, bend, deform, or otherwise change shape during normal operation. The body **64** may include a bore **55** extending through the body **64** from the first side **71** to the second side **72** and/or a bore **55** extending through the body **64** from the third side **73** to the fourth side **74**.

The body **64** may be formed of a conductive material, including, but not limited to, aluminum, beryllium, brass, chromium, copper, gold, iron, nickel, palladium, platinum, silver, steel, tin, tungsten, or alloys thereof, or the like. In some embodiments, the body **64** may be copper or a copper alloy, for example, a beryllium copper material, or steel, for example a stainless steel alloy. Conductive materials are considered to be materials which readily pass an electrical current therethrough.

In some embodiments, the body **64** may be symmetrical about two perpendicular planes of symmetry, i.e., a first plane parallel to the first and second sides **71**, **72** and a second plane parallel to the third and fourth sides **73**, **74**. The body **64** may be bolted to a conductive surface by passing a bolt (See FIG. **3**) through a bore **55**. Thus, depending on the desired orientation of the body **64** the bolt may be passed through either of the bores **55**. Accordingly, as certain features of the body **64** are described, it should be noted that although not necessarily shown in the figures, these features may additionally be found on the opposing side of the planes of symmetry of the body **64**.

The cavity **62** in the body **64** may be configured to removably receive the nugget **40** and the resilient clip **80** therein to complete an electrical pathway from the nugget **40** to the receptacle **60**. The cavity **62** may extend from the first side **71** of the body **64** to the second side **72** of the body **64**. As the body **64** may be symmetrical about two perpendicular planes of symmetry, the cavity **62** may be configured such that the nugget **40** and the resilient clip **80** may be inserted into the cavity **62** of the body **64** from either the first side **71** of the body **64** or the second side **72** of the body **64**. The cavity **62** may include a beveled opening **68** opening into the cavity **62** from the first side **71** and/or a beveled opening **68** opening into the cavity **62** from the second side **72** to facilitate insertion of the nugget **40** and resilient clip **80**.

The cavity **62** may be defined by a plurality of walls or surfaces, including a rear surface **61**, first and second side surfaces **63**, and third and fourth side surfaces **67** nonplanar with the first and second side surfaces **63**. In some embodiments, the cavity **62** may open out to the first end **75** of the body **64** in which case the third and fourth side surfaces **67** may extend to and intersect the first end **75** of the body **64**. However, in other embodiments, the cavity **62** may be fully enclosed at the first end **75**.

As shown in FIG. **5**, the first and second side surfaces **63** may be perpendicular to the rear surface **61** and/or the third and fourth side surfaces **67** may be perpendicular to the rear surface **61**. Accordingly, the first and second side surfaces **63** may be parallel to, but offset from the third and fourth side surfaces **67**, forming a jog **69** in the sides of the cavity **62**. Thus, the distance across the cavity **62** between the first and second side surfaces **63** may be greater than the distance across the cavity **62** between the third and fourth side surfaces **67**, providing a transition at the jog **69**.

The cavity **62** may include sloped surfaces **65** at the jog **69** to facilitate entry into the cavity **62**. Furthermore, the cavity **62** may include recesses, edges or lips **66** formed in the jog **69** of the sides of the cavity **62** for providing an interlocking geometry with the resilient clip **80**.

FIG. **7A** illustrates one possible manufacturing process for providing a nugget **40** on the end of the electrical leads **25**. In some instances, the nugget **40** may be formed of a plurality of wire strands **27** of the electrical leads **25**. For instance, the electrical leads **25** may be of multifilament construction and the nugget **40** may be formed by ultrasonically welding together a plurality of wire strands or filaments **27** of the electrical leads **25** into a formed shape. For example, the end portions of the electrical leads **25** may be placed in a fixture and simultaneously subjected to high-frequency ultrasonic acoustic vibrations (e.g., 20,000 Hz-40,000 Hz) and pressure for a duration of time to ultrasonically weld the wire strands or filaments **27** into the formed shape of the nugget **40** without reaching the melt temperature of the metal forming the wire strands or filaments **27**. The ultrasonic vibrations and pressure cause surface oxides and contaminates on the surfaces of the filaments **27** to break up and disperse to provide clean base metal surfaces in which diffusion bonding occurs (i.e., atoms of adjacent filaments **27** diffuse across the interface between filaments **27**, forming

a metallurgical bond). The applied pressure may press the filaments **27** into the desired formed shape.

Thus, the resultant nugget **40** may be a monolithic structure of the electrical leads **25**, integrally formed from the end portions of the filaments **27** of the electrical leads **25**. In some instances, the nugget **40** may have a rectangular block shape having flat front and rear surfaces **42**, **44**. The formed nugget **40** may also include an interlocking structure to mate with and interlock with the resilient clip **80**. For example, the nugget **40** may be formed with projecting portions **45** formed in the side surfaces **46** of the nugget **40** forming edges **49** and notches **48**. Notches **48** may be any desired shape, but in some instances the notches **48** may be wedge or dovetail shaped having a wider portion proximate the rear surface **44** and a narrower portion proximate the front surface **42**. The edges **49** may define a stepped transition of the front surface **42** and side surfaces **46**. Thus, the edges **49** may be considered a stepped portion of the front surface **42**.

In other embodiments, the electrical leads **25** may be of monofilament construction and the nugget **40** may be formed by ultrasonically welding together the monofilaments of the electrical leads **25** into a formed shape, or forming the end portion of a monofilament of an electrical lead **25** into a formed shape. Thus, the resultant nugget **40** may be a monolithic structure of the electrical lead(s) **25**, integrally formed from the end portion(s) of the electrical lead(s) **25**.

The nugget **40**, as well as the electrical leads **25** from which the nugget **40** is formed, may be formed of a conductive material, including, but not limited to those materials listed above. In other embodiments, the nugget **40** may be separately formed and subsequently secured to the electrical leads **25** in a conventional manner, such as crimping, welding, soldering or brazing. In such instances, the nugget **40** may similarly be formed of a conductive material.

FIG. **7**B illustrates another possible manufacturing process for providing a nugget **140** on the end of the electrical leads **25**. In this embodiment, the nugget **140** may be formed by securing the end portion of the electrical lead(s) **25** into a channel **147** of a preformed sleeve **143**. The sleeve **143** may be stamped or otherwise formed from a thin sheet of metal into a formed shape having a back portion **152** and opposing side portions or wings **151** extending from the back portion **152** to form a U-shaped member with the channel **147** defined between the opposing side portions **151**. The side portions **151** may include cut outs **153**, which when the electrical leads **25** are secured to the sleeve **143**, may define the notches **148**. The sleeve **143** may be preformed to have a length L, width W, and height H of controlled predetermined dimensions sized and configured to be inserted into a cavity of a receptacle having known dimensions sized and configured to accommodate the dimensions of the sleeve **143**.

To form the nugget **140**, the end portions of the electrical leads **25** may be inserted into the channel **147** of the sleeve **143** and secured thereto, such as by crimping, welding, soldering or brazing without changing the dimensions of the sleeve **143**. In some instances, the electrical leads **25** may be welded in the channel **147** using an ultrasonic welding technique as described above.

In some instances, the formed nugget **140** may have a rectangular block shape having flat front and rear surfaces **142**, **144**. The formed nugget **140**, similar to the nugget **40**, may also include an interlocking structure to mate with and interlock with the resilient clip **80**. For example, the nugget **140** may be formed with projecting portions **145** formed in the side surfaces **146** of the nugget **140** forming edges **149** and notches **148**. Notches **148** may be any desired shape, but in some instances the notches **148** may be wedge or dovetail shaped having a wider portion proximate the rear surface **144** and a narrower portion proximate the front surface **142**. The edges **149** may define a stepped transition of the front surface **142** and side surfaces **146**. Thus, the edges **149** may be considered a stepped portion of the front surface **142**.

Accordingly, the side portions **151** of the sleeve **143** may define the projecting portions **145**, with the cut outs **153** defining the notches **148** in the sides of the nugget **140**, while the back portion **152** of the sleeve **143** may define the rear surface **144** of the formed nugget **140**. When secured in the channel **147**, the end portion of the lead(s) **25** form a core **141** of the nugget **140**, surrounded on three sides by the sleeve **143** (i.e. rear and opposing sides of the core **141**). Thus, the front surface **142** of the nugget **140** (with the exception of the edges **149**) may be defined by the core **141**.

The nugget **140** may have a length L' substantially equal to the length L of the sleeve **143**, and a width W' substantially equal to the width W of the sleeve **143**. Furthermore, the height H of the edges **149** from the rear surface **144** may be predetermined and controlled by the height H of the side portions **151** of the sleeve **143**. Thus, the length L' of the nugget **140**, the width W' of the nugget **140**, and height H of the edges **149** may be dictated and determined by the manufactured dimensions of the sleeve **143**, regardless of the gauge, size, quantity (i.e., volume) of the leads **25** positioned in the channel **147**. Accordingly, the only dimension of the formed nugget **140** which may be varied based on the gauge, size, quantity (i.e., volume) of the leads **25** positioned in the channel **147** may be the height H' of the nugget **140** from the rear surface **144** to the front surface **142**. Thus, the height H' of the nugget **140** may vary based on the gauge, size, and/or quantity (i.e., volume) of the leads **25** positioned in the channel **147** without altering the other dimensions of the nugget **140** predetermined to mate with a resilient clip **80** of predetermined size and shape, and in combination with the resilient clip **80** of predetermined size and shape may be insertable into a cavity **62** of a receptacle **60** having known dimensions.

The side of the core **141** opposite the base portion **152** of the sleeve **143** may extend to any height H', and need not be precisely controlled, as this portion of the core **141** does not engage another component. In other words, the portion of the core **141** extending out of the channel **147** may fit between the inner arms **86** of the resilient clip **80**, with the inner arms **86** contacting the edges **149** defined by the sleeve **143**.

Accordingly, a single sized/shaped (e.g., universal) resilient clip **80** and single sized/shaped (e.g., universal) cavity **62** of a receptacle **60** may be used regardless of the gauge, size, quantity (i.e., volume) of the leads **25** to which the sleeve **143** is secured to as the dimensions of the sleeve **143** may dictate or control the size of the formed nugget **140** for insertion into the cavity **62**. Thus, multiple sizes of nuggets **140** may not be needed to accommodate a variety of gauges, sizes and/or quantities of leads **25**, instead a single size of sleeve **143** and single size of resilient clip **80** may be used with a single size of cavity **62** of a receptacle **60** to provide the quick disconnect assembly **50**.

In some instances, it may be desirable to plate the rear surface **144** of the nugget **140** (i.e., the rear surface of the back portion **152**) with a thin layer of conductive material to enhance the electrical conductivity of the nugget **140**. For example, the rear surface **144** may include a thin layer of silver plating, or other conductive material in some instances.

FIGS. **8-12** further illustrate features of the resilient clip **80**. The resilient clip **80** may be formed of a resilient material giving the resilient clip **80** a degree of springiness (i.e., elastic flexibility) such that the resilient clip **80** can undergo elastic deformation or deflection with an applied force to a non-equilibrium position, yet return to its equilibrium position when the applied force is removed. For example, the resilient clip **80** may be formed of aluminum, beryllium, brass, chromium, copper, gold, iron, nickel, palladium, platinum, silver, steel, tin, tungsten, or alloys thereof, or the like. In some embodiments, the resilient clip **80** may be copper or a copper alloy, for example, a beryllium copper material or a spring steel, such as 17-7 stainless steel. In some embodiments, the resilient clip **80** need not be conductive. For example, in some instances, the resilient clip **80** may be formed of a polymeric material, or a composite of a polymeric material and a metallic material. For instance, the resilient clip **80** may include a polymeric material covering or encapsulating a metallic core, such as a metal wire or plate embedded in a polymeric material covering.

The resilient clip **80** may include a base **81** having a front portion **82** at an oblique angle to a rear portion **83** with a living hinge **84** between the front portion **82** and the rear portion **83** to provide a flexing region between the front portion **82** and the rear portion of the base **81**.

The resilient clip **80** may include a pair of outer arms **85** extending from the rear portion **83** and a pair of inner arms **86** extending from the front portion **82**. The inner arms **86** may be positioned between the outer arms **85**. In other words, the inner arms **86** may be positioned a first distance apart, while the outer arms **85** may be positioned a second distance apart greater than the first distance between the inner arms **86**. Thus, the outer arms **85** may overlap with the inner arms **86** when viewed from the side.

The outer arms **85** may include wings **89** at the upper end of the outer arms **85** to help stabilize the resilient clip **80** and appropriately orient the resilient clip **80** in the cavity **62**. For example, the wings **89** may be configured to come into contact with the beveled opening **68** of the cavity **62** when the resilient clip **80** is properly positioned in the cavity **62**.

The outer arms **85** may include frontwardly extending tabs **87** extending from a front edge **90** of the outer arms **85**. Additionally, the inner arms **86** may include rearwardly extending tabs **88** extending from a rear edge **91** of the inner arms **86**. As will be discussed further herein, the frontwardly extending tabs **87** may be configured to interlock with mating geometry (e.g., the recesses or lips **66**) in the cavity **62** of the receptacle **60**. Likewise, the rearwardly extending tabs **88** may be configured to interlock with mating geometry (e.g., the notches **48**) of the nugget **40**.

In some embodiments the resilient clip **80** may be formed from a piece of sheet metal, such as a sheet of stainless steel. However, in other embodiments, the resilient clip **80** may be formed of a polymeric material, and thus need not be electrically conductive. As shown in FIG. **13**, the resilient clip **80** may initially be cut or stamped in a flattened out state from a sheet of metal or otherwise removed from a sheet of metal. The resilient clip **80** may subsequently undergo additional processing to form the resilient clip **80** into its final formed shape. For example, the outer arms **85** and inner arms **86** may be bent upward relative to the base **81**, forming a generally U-shaped structure. Additionally, the front portion **82** of the base **81** may be bent relative to the rear portion **83** of the base **81** along the living hinge **84** such that the front portion **82** is at an oblique angle to the rear portion **83**. The wings **89** may also be bent outward from the outer arms **85**. Although the resilient clip **80** may be formed of a single piece of material formed from a piece of sheet metal, in other embodiments the resilient clip **80** may be formed of multiple pieces, welded, soldered, or brazed together, or otherwise united to form the resilient clip **80**. In instances in which the resilient clip **80** is formed of a polymer material, the resilient clip **80** may be formed in a molding process, such as injection molding.

As shown in FIGS. **14-15**, the resilient clip **80** may be removably coupled to the nugget **40**, with the rearwardly extending tabs **88** extending into and interlocking with the notches **48** of the nugget **40**. The notches **48** and tabs **88** may be complementarily formed such that the tabs **88** may not be removed from the notches **48** in a direction toward the front surface **42** of the nugget **40**. For example, the notches **48** and tabs **88** may be wedge shaped, such that a portion of a tab **88** is sized larger than a portion of a notch **48**.

When coupled to the nugget **40**, the rear edges **91** of the inner arms **86** may face and contact the edges **49** of the projecting portions **45** of the nugget **40** while the outer arms **85** are positioned outward of the projecting portions **45** and facing the side surfaces **46** of the nugget **40**. Furthermore, the end of the nugget **40** may contact and press against the rear portion **83** of the base **81** of the resilient clip **80**. When coupled to the nugget **40**, no portion of the resilient clip **80** may extend rearward of the rear surface **44** of the nugget **40**. In other words, the entire resilient clip **80** may be positioned forwardly of the rear surface **44** toward the front surface **42** of the nugget **40** when coupled thereto. Such a configuration may resiliently couple the resilient clip **80** to the nugget **40** and maintain a residual force between the resilient clip **80** and the nugget **40**.

With the resilient clip **80** coupled to the nugget **40**, the combination of the resilient clip **80** and nugget **40** may be inserted into the cavity **62** of the receptacle **60** (e.g., the body **64**). As shown in FIG. **16**, the resilient clip **80** may be sized and shaped such that the outer arms **85** fit in the enlarged portion of the cavity **62** defined between the first and second side surfaces **63** while the inner arms **86** fit in the smaller portion of the cavity **62** defined between the third and fourth side surfaces **67**. Thus, the outer arms **85** may be interposed between the side surfaces **46** of the nugget **40** and the first and second side surfaces **63** of the cavity **62**, while the inner arms **86** may extend from the edges **49** formed in the front surface **42** of the nugget **40** into the region of the cavity **62** defined between the third and fourth side surfaces **67**. Accordingly, the outer surfaces **92** of the outer arms **85** may face and/or contact the first and second side surfaces **63** of the cavity **62** and the outer surfaces **93** of the inner arms **86** may face and/or contact the third and fourth side surfaces **67** of the cavity **62**. When properly positioned in the cavity **62**, the wings **89** may come into contact with the beveled opening **68** of the cavity **62** to prevent further advancement of the resilient clip **80** and nugget **40** into the cavity **62**.

As noted previously, the body **64**, and thus the cavity **62** may be symmetrical such that the nugget **40** and the resilient clip **80** may be inserted into the cavity **62** of the body **64** from either the first side **71** of the body **64** or the second side **72** of the body **64** depending on the desired orientation of the body **64** mounted to the base member or yoke **30**, brush holder **12**, or other component of the brush holder assembly **10**.

Additional features of the interaction of the components of the quick disconnect assembly **50** when removably coupled together will now be further described with reference to the cross-sectional views shown in FIGS. **17-19**.

When the nugget **40** and resilient clip **80** are positioned in the cavity **62**, the resilient clip **80** is displaced from its equilibrium position to provide a force that urges the rear surface **44** of the nugget **40** into direct contact with the rear surface **61** of the cavity **62** with a force F**1**, providing an electrically conductive pathway from the nugget **40** to the body **64**. This force F**1** between the rear surface **44** of the nugget **40** and the rear surface **61** of the cavity **62** may be maintained with the compressed resilient clip **80**. For example, when the resilient clip **80** is positioned in the cavity **62** the resilient clip **80** is compressed (i.e., the inner arms **86** are deflected frontwardly while the outer arms **85** are deflected rearwardly at the living hinge **84** between the front portion **82** of the base **81** and the rear portion **83** of the base **81**), providing an elastic force in the resilient clip **80**. Thus, the rear edges **91** of the inner arms **86** press against the edges **49** of the projecting portions **45** of the nugget **40** to exert a force F**2**, while the front edges **90** of the outer arms **85** press against the jogs **69** in the sides of the cavity **62** to exert a force F**3**. Thus, when inserted into the cavity **62**, the resilient clip **80** may be elastically deformed and loaded into compression to generate the exerted forces F**2**, F**3** to provide the force F**1** at the interface between the rear surface **44** of the nugget **40** and the rear surface **61** of the cavity **62**.

Due to the overlapping nature of the inner arms **86** with the outer arms **85**, when the resilient clip **80** is elastically deformed in compression, the rear edges **91** of the inner arms **86** move closer to the front edges **90** of the outer arms **85**. However, in other embodiments, the resilient clip **80** may be configured such that the rear edges **91** of the inner arms **86** move away from the front edges **90** of the outer arms **85** when the resilient clip **80** is elastically deformed in compression.

Furthermore, when inserted into the cavity **62**, the frontwardly extending tabs **87** may mate with and interlock with the recesses or lips **66** in the cavity **62** of the body **64** to inhibit the resilient clip **80** from being removed from the cavity **62**. In order to remove the resilient clip **80**, and thus the nugget **40**, an external force would need to be applied to the outer arms **85** to move the outer arms **85** rearwardly (toward the rear surface **61** of the cavity **62**) until the frontwardly extending tabs **87** clear or disengage from the recesses or lips **66** in the cavity **62**. The applied force may be exerted on the wings **89** to effect movement of the outer arms **85** rearwardly.

In use, when it is determined that a brush **18** of the brush holder assembly **10** needs to be removed or replaced, the electrical connection to/from the brush **18** may be quickly and efficiently disconnected with the quick disconnect assembly **50**. For example, to remove a first brush **18** from the brush holder assembly **10**, the first brush **18** may be removed from the brush holder **12** and the end of the electrical lead **25**, such as the nugget **40**, along with a first resilient clip **80** coupled to the nugget **40**, may be removed from the cavity **62** of the receptacle **60** (e.g., the body **64**).

Thus, the brush **18** with the electrical lead **25** extending therefrom with the nugget **40** at the end of the electrical lead **25**, along with the resilient clip **80**, may be removed and replaced as an assembly. Thus, every time a brush **18** is replaced with a new brush **18**, a new resilient clip **80** may be used to reduce the likelihood of failure of the resilient clip **80** due to fatigue.

To remove the resilient clip **80**, and thus the nugget **40**, an external force may be applied to the outer arms **85** (e.g., via the wings **89**) to move the outer arms **85** rearwardly (toward the rear surface **61** of the cavity **62**) until the frontwardly extending tabs **87** clear or disengage the recesses or lips **66** in the cavity **62**. Once the tabs **87** clear the recesses or lips **66** in the cavity **62**, the nugget **40** along with the resilient clip **80** coupled thereto may be removed from the cavity **62**.

A second, replacement brush **18** may then be inserted into the brush holder **12** and the end (e.g., the nugget **40**) of the electrical lead **25** extending from the second brush **18**, along with a second, new resilient clip **80** coupled to the nugget **40**, may be inserted into the cavity **62** of the receptacle **60** (e.g., the body **64**). The nugget **40** and resilient clip **80** may be inserted into the cavity **62** until the frontwardly extending tabs **87** mate with and interlock with the recesses or lips **66** in the cavity **62** of the body **64** to releasably couple the nugget **40** and resilient clip **80** in the cavity **62**.

With the nugget **40** and resilient clip **80** positioned in the cavity **62**, the compressed resilient clip **80**, which has been displaced from its equilibrium position, provides an elastic force that urges the rear surface **44** of the nugget **40** into direct contact with the rear surface **61** of the cavity **62** to provide an electrically conductive pathway from the nugget **40** to the body **64**. Thus, when inserted into the cavity **62**, the resilient clip **80** may be elastically deformed and loaded into compression to retain the resilient clip **80** and the nugget **40** in the cavity **62** and the nugget **40** in electrical contact with the rear surface **61** of the cavity **62** to allow an electrical current to pass therebetween. Thus, an electrical pathway may be provided from the second brush **18**, through the electrical lead **25**, to a surface of the receptacle **60** from the nugget **40**, and on to the base member or yoke **30**.

Another embodiment of a receptacle **160** for use in a quick disconnect assembly in an electrical pathway of a brush holder assembly will now be described with reference to FIG. **20**. The receptacle **160** may be similar to the receptacle **60** in many respects. For instance, the receptacle **160** may be formed of a body **164**, such as a rigid metal block, having a first side **171**, a second side **172** opposite the first side **171**, a third side **173**, a fourth side **174** opposite the third side **173**, a first end **175** and a second end **176** opposite the first end **175**. The body **164**, in the form of a rigid metal block, may be an inert structure which does not flex, bend, deform, or otherwise change shape during normal operation. The body **164** may include one or more bores **155** extending through the body **164** for receiving a bolt or other fastener to secure the body **164** to a component of a brush holder assembly. The body **164** may be formed of a conductive material, such as those materials discussed above.

The cavity **162** in the body **164** may be configured to removably receive the nugget **40** of an electrical lead **25** and a resilient clip **180** therein to complete an electrical pathway from the nugget **40** to the receptacle **160**. The cavity **162** may include a beveled opening **168** opening into the cavity **162** from the first side **171** and/or a beveled opening **168** opening into the cavity **162** from the second side **172** to facilitate insertion of the nugget **40** and resilient clip **180**.

As shown in FIG. **21**, similar to the cavity **62**, the cavity **162** may be defined by a plurality of walls or surfaces, including a rear surface **161**, first and second side surfaces **163**, and third and fourth side surfaces **167** nonplanar with the first and second side surfaces **163**. The first and second side surfaces **163** may be parallel to, but offset from the third and fourth side surfaces **167**, forming a jog **169** in the sides of the cavity **162** providing a transition at the jog **169**. The cavity **162** may include sloped surfaces **165** at the jog **169** to facilitate entry into the cavity **162**. Furthermore, the cavity **162** may include recesses, edges or lips **166** formed in the jog **169** of the sides of the cavity **162** for providing an interlocking geometry with the resilient clip **180**.

One or more of the surfaces of the body **164** may include a plurality of crush points **136** extending from the surface(s) configured to be pressed against another component of the brush holder assembly **10** (e.g., the base member or yoke **30** or brush holder **12**) to enhance electrical connectivity between the body **164** and the other component of the brush holder assembly **10** (e.g., the base member or yoke **30** or brush holder **12**) in the electrical current pathway. The crush points **136** may be configured to be deformed or crushed when compressed against the conductive surface of the other component. The crush points **136** may provide a heat sink between the body **164** and the conductive surface against which the body **164** is pressed against. In such an embodiment, the electrical contact between the body **164** and the conductive surface may be spread over a larger interface.

In some instances, the crush points **136** may be small protuberances **138** protruding from an otherwise flat surface of the body **164**. Some possible shapes of the protuberances **138** include conical, pyramidal, or hemispherical shapes. In other instances, the protuberances **138** may be formed as ridges on the surface(s) of the body **164** or portions of the body **164** remaining between grooves formed in the body **164**. The small protuberances **138** may be arranged in a regular pattern (e.g., a rectangular array) or irregularly arranged on the surface(s). In some instances, the crush points **136** may be knurlings in the surface(s) of the body **164**, or other surface roughenings. The crush points **136** may be cast into the body **164** while forming the body **164**, or the crush points **136** may be added to the body **164** in a subsequent process, such as a machining process.

The resilient clip **180** configured for use with the body **164** is illustrated in FIG. **22**. The resilient clip **180**, which may be formed of a resilient material giving the resilient clip **180** a degree of springiness (i.e., elastic flexibility), may be similar to the resilient clip **80** in many respects. For instance, the resilient clip **180** may include a base **181** having a front portion **182** at an oblique angle to a rear portion **183** with a living hinge **184** between the front portion **182** and the rear portion **183** to provide a flexing region between the front portion **182** and the rear portion of the base **181**.

The resilient clip **180** may include a pair of outer arms **185** extending from the rear portion **183** and a pair of inner arms **186** extending from the front portion **182**. The outer arms **185** may include wings **189** at the upper end of the outer arms **185**. The inner arms **186** may be positioned between the outer arms **185**. In other words, the inner arms **186** may be positioned a first distance apart, while the outer arms **185** may be positioned a second distance apart greater than the first distance between the inner arms **186**. Thus, the outer arms **185** may overlap with the inner arms **186** when viewed from the side.

The outer arms **185** may include frontwardly extending tabs **187**, configured to interlock with mating geometry (e.g., the recesses or lips **66**) in the cavity **62**, extending from a front edge **190** of the outer arms **185**. Additionally, the inner arms **186** may include rearwardly extending tabs **188**, configured to interlock with mating geometry (e.g., the notches **48**) of the nugget **40**, extending from a rear edge **191** of the inner arms **186**.

The resilient clip **180** may be removably coupled to the nugget **40**, in a similar fashion to that described above regarding the resilient clip **80**. When coupled to the nugget **40**, the rear edges **191** of the inner arms **186** may face and contact the edges **49** of the projecting portions **45** of the nugget **40** while the outer arms **185** are positioned outward of the projecting portions **45** and facing the side surfaces **46** of the nugget **40**. Furthermore, the end of the nugget **40** may contact and press against the rear portion **183** of the base **181** of the resilient clip **180**. Such a configuration may resiliently couple the resilient clip **180** to the nugget **40** and maintain a residual force between the resilient clip **180** and the nugget **40**.

With the resilient clip **180** coupled to the nugget **40**, the combination of the resilient clip **180** and nugget **40** may be inserted into the cavity **162** of the receptacle **160** (e.g., the body **164**). As shown in FIG. **23**, the resilient clip **180** may be sized and shaped such that the outer arms **185** fit in the enlarged portion of the cavity **162** defined between the first and second side surfaces **163** while the inner arms **186** fit in the smaller portion of the cavity **162** defined between the third and fourth side surfaces **167**. Thus, the outer arms **185** may be interposed between the side surfaces **46** of the nugget **40** and the first and second side surfaces **163** of the cavity **162**, while the inner arms **186** may extend from the edges **49** formed in the front surface **42** of the nugget **40** into the region of the cavity **162** defined between the third and fourth side surfaces **167**. When properly positioned in the cavity **162**, the wings **189** may come into contact with the beveled opening **168** of the cavity **162** to prevent further advancement of the resilient clip **180** and nugget **40** into the cavity **162**.

As shown in FIGS. **24-26**, when the nugget **40** and resilient clip **180** are positioned in the cavity **162**, the resilient clip **180** is displaced from its equilibrium position to provide a force that urges the rear surface **44** of the nugget **40** into direct contact with the rear surface **161** of the cavity **162** with a force F**1**, providing an electrically conductive pathway from the nugget **40** to the body **164**. This force F**1** between the rear surface **44** of the nugget **40** and the rear surface **161** of the cavity **162** may be maintained with the compressed resilient clip **180**. In maintaining the elastic compression of the resilient clip **180**, the rear edges **191** of the inner arms **186** press against the edges **49** of the projecting portions **45** of the nugget **40** to exert a force F**2**, while the front edges **190** of the outer arms **185** press against the jogs **169** in the sides of the cavity **162** to exert a force F**3**. Thus, when inserted into the cavity **162**, the resilient clip **180** may be elastically deformed and loaded into compression to generate the exerted forces F**2**, F**3** to provide the force F**1** at the interface between the rear surface **44** of the nugget **40** and the rear surface **161** of the cavity **162**.

When inserted into the cavity **162**, the frontwardly extending tabs **187** may mate with and interlock with the recesses or lips **166** in the cavity **162** of the body **164** to inhibit the resilient clip **180** from being removed from the cavity **162**. In order to remove the resilient clip **180**, and thus the nugget **40**, an external force would need to be applied to the outer arms **185** to move the outer arms **185** rearwardly (toward the rear surface **161** of the cavity **162**) until the frontwardly extending tabs **187** clear the recesses or lips **166** in the cavity **162**. The applied force may be exerted on the wings **189** to effect movement of the outer arms **185** rearwardly.

In other embodiments, the body **64**, **164** may be formed without bores **55**, **155** and secured to or incorporated with either the stationary member or yoke **30** or the brush holder **12**, or other component of the brush holder assembly **10**, by other means, such as welding. In such embodiments, the body **64**, **164** need only be large enough to include the cavity **62**, **162**. For example, FIG. **27** illustrates one embodiment in which the body **264**, having the cavity **262** for removably receiving and an end of the electrical lead **25**, such as the nugget **40**, **140** and the resilient clip **80**, **180** is secured to the stationary member or yoke **30**. In another embodiment,

shown in FIG. **28**, the body **364** may be formed of two separate pieces, **391**, **392** secured to either the stationary member or yoke **30** or the brush holder **12**, or other component of the brush holder assembly **10** such as by welding. Thus, the cavity **362** may be partially defined by the conductive surface of the base member or yoke **30**, as well as interior surfaces of the two separate pieces, **391**, **392** of the body **364**. Accordingly, a surface of the nugget **40**, **140** may directly contact the conductive surface of the base member or yoke **30** when inserted into the cavity **362**. It is noted that in such embodiments, the cavity **262**, **362** may be configured similar to the cavity **62**, **162** described herein in order to receive the nugget **40**, **140** and resilient clip **80**, **180**.

In other embodiments, such as shown in FIG. **29**, a receptacle **460** sized and shaped to receive the nugget **40**, **140** and resilient clip **80**, **180** therein may be formed integrally with a component of the brush holder assembly **10**, such as the brush holder **12** or other component such as the base member or yoke **30**. In other words, the brush holder **12**, or other component such as the base member or yoke **30**, may be formed with the cavity **462** defining the receptacle **460** as a unitary portion of the brush holder **12**, or other component such as the base member or yoke **30**. When inserted into the cavity **462** of the receptacle **460**, a surface of the nugget **40**, **140** may directly contact the conductive surface of the base member or yoke **30**, providing an electrically conductive pathway directly therebetween. It is noted that in such embodiments, the cavity **462** may be configured similar to the cavity **62**, **162** described herein in order to removably receive the nugget **40**, **140** and resilient clip **80**, **180** therein.

Those skilled in the art will recognize that the present invention may be manifested in a variety of forms other than the specific embodiments described and contemplated herein. Accordingly, departure in form and detail may be made without departing from the scope and spirit of the present invention as described in the appended claims.

What is claimed is:

1. A brush holder assembly comprising:
- a brush holder mounted to a stationary member;
- a brush slidably disposed in the brush holder;
- an electrical lead having a first end secured to the brush and a second end;
- a resilient clip removably coupled to the second end of the electrical lead; and
- a receptacle for removably receiving *both* the second end of the electrical lead *within the receptacle* and the resilient clip **[**therein**]** *within the receptacle*;
- wherein an electrical pathway is provided from the brush, through the electrical lead, to a surface of the receptacle;
- wherein the resilient clip and the second end of the electrical lead are removable from the receptacle simultaneously as a unit;
- *wherein the second end of the electrical lead includes a nugget;*
- *wherein the nugget is a separately formed structure secured to filaments of the electrical lead.*

2. **[**The brush holder assembly of claim **1**,**]** *A brush holder assembly comprising:*
- *a brush holder mounted to a stationary member;*
- *a brush slidably disposed in the brush holder;*
- *an electrical lead having a first end secured to the brush and a second end;*
- *a resilient clip removably coupled to the second end of the electrical lead; and*
- *a receptacle for removably receiving the second end of the electrical lead and the resilient clip therein;*
- *wherein an electrical pathway is provided from the brush, through the electrical lead, to a surface of the receptacle;*
- *wherein the resilient clip and the second end of the electrical lead are removable from the receptacle simultaneously as a unit; and*
- wherein the resilient clip urges a surface of the second end of the electrical lead into direct contact with the surface of the receptacle.

3. The brush holder assembly of claim **2**, wherein the second end of the electrical lead includes a nugget formed of a plurality of wire strands of the electrical lead.

4. The brush holder assembly of claim **3**, wherein the nugget is formed by ultrasonically welding together the plurality of wire strands into a formed shape.

5. A brush holder assembly comprising:
- a brush holder mounted to a stationary member;
- a brush slidably disposed in the brush holder;
- an electrical lead having a first end secured to the brush and a second end;
- a resilient clip removably coupled to the second end of the electrical lead; and
- a receptacle for removably receiving the second end of the electrical lead and the resilient clip therein;
- wherein an electrical pathway is provided from the brush, through the electrical lead, to a surface of the receptacle;
- wherein the resilient clip urges a surface of the second end of the electrical lead into direct contact with the surface of the receptacle;
- wherein the second end of the electrical lead includes a nugget formed of a plurality of wire strands of the electrical lead;
- wherein the nugget is formed by securing end portions of the electrical lead in a channel of a U-shaped sleeve.

6. The brush holder assembly of claim **5**, wherein a surface of the U-shaped sleeve contacts the surface of the receptacle.

7. The brush holder assembly of claim **6**, wherein the resilient clip faces three surfaces of the nugget, the three surfaces including a front surface opposite the surface of the U-shaped sleeve contacting the surface of the receptacle and first and second side surfaces extending between the front surface and the surface of the U-shaped sleeve contacting the surface of the receptacle.

8. The brush holder assembly of claim **5**, wherein the U-shaped sleeve is configured to accept electrical leads of various gauges, sizes or quantities.

9. The brush holder assembly of claim **1**, wherein the receptacle includes a body with a cavity formed therein for removably receiving *both* the second end of the electrical lead *within the cavity* and the resilient clip *within the cavity*.

10. The brush holder assembly of claim **9**, wherein the body is bolted to either the stationary member or the brush holder.

11. The brush holder assembly of claim **1**, wherein the receptacle is integrally formed in either the stationary member or the brush holder.

12. The brush holder assembly of claim **1**, wherein during replacement of the brush, the resilient clip is decoupled from the receptacle and removed with the brush and electrical lead.

13. An assembly for providing an electrical current pathway through a brush holder assembly, the assembly comprising:

a brush for contacting a moving conductive surface;

an electrical lead having a first end secured to the brush and a second end;

a nugget at the second end of the electrical lead;

a resilient clip removably coupled to the nugget; and

a receptacle having a cavity for removably receiving the nugget and the resilient clip therein;

wherein the resilient clip urges a surface of the nugget into direct contact with a surface of the receptacle partially defining the cavity;

wherein an electrical current pathway is provided from the brush through the electrical lead to the nugget, and from the surface of the nugget to the surface of the receptacle.

14. The assembly of claim **13**, wherein the nugget includes a first side, a second side opposite the first side, a third side extending between the first side and the second side, and a fourth side opposite the third side extending between the first side and the second side;

wherein the resilient clip faces or contacts each of the first, second and third sides of the nugget.

15. The assembly of claim **14**, wherein the fourth side of the nugget includes the surface in direct contact with the surface of the receptacle.

16. The assembly of claim **13**, wherein the resilient clip includes one or more tabs configured to interlock in one or more recesses formed in the nugget.

17. The assembly of claim **16**, wherein the resilient clip includes one or more tabs configured to interlock with one or more recesses formed in the receptacle.

18. The assembly of claim **13**, wherein the nugget is formed by ultrasonically welding together a plurality of wire strands of the electrical lead into a formed shape.

19. The assembly of claim **13**, wherein the receptacle includes a body having the cavity extending from a first surface of the body to a second surface of the body, the body being symmetrical about two perpendicular planes of symmetry such that the nugget and the resilient clip may be inserted into the cavity of the body from either the first surface of the body or the second surface of the body.

20. A method of replacing a brush in a brush holder of a brush holder assembly, the method comprising:

removing a first brush from the brush holder by decoupling an end of a first electrical lead extending from the first brush simultaneously along with a first resilient clip from a receptacle;

inserting a second brush into the brush holder, the second brush having a second electrical lead extending from the brush and a second resilient clip coupled to an end of the second electrical lead; and

inserting *both* the end of the second electrical lead *into a cavity of a receptacle* and the second resilient clip into **[**a**]** *the* cavity of **[**a**]** *the* receptacle to provide an electrical pathway from the second brush, through the second electrical lead, to a surface of the receptacle*;*

wherein the end of the second electrical lead includes a nugget;

wherein the nugget is a separately formed structure secured to filaments of the second electrical lead.

21. The method of claim **20**, wherein the end of the second electrical lead and the second resilient clip are removably retained in the cavity of the receptacle by a spring force applied by the second resilient clip.

22. The method of claim **21**, wherein the second resilient clip is removably coupled to a shaped nugget at the end of the second electrical lead that is integrally formed from a plurality of wire strands of the electrical lead.

23. The method of claim **22**, wherein the second resilient clip and the shaped nugget include interlocking geometry to retain the second resilient clip coupled to the shaped nugget.

24. A method of replacing a brush in a brush holder of a brush holder assembly, the method comprising:

removing a first brush from the brush holder by decoupling an end of a first electrical lead extending from the first brush along with a first resilient clip from a receptacle;

inserting a second brush into the brush holder, the second brush having a second electrical lead extending from the brush and a second resilient clip coupled to an end of the second electrical lead; and

inserting the end of the second electrical lead and the second resilient clip into a cavity of a receptacle to provide an electrical pathway from the second brush, through the second electrical lead, to a surface of the receptacle;

wherein the end of the second electrical lead and the second resilient clip are removably retained in the cavity of the receptacle by a spring force applied by the second resilient clip;

wherein the second resilient clip is removably coupled to a shaped nugget at the end of the second electrical lead that is integrally formed from a plurality of wire strands of the electrical lead;

wherein the second resilient clip urges a surface of the shaped nugget into direct contact with the surface of the receptacle.

25. An assembly for providing an electrical current pathway through a brush holder assembly, the assembly comprising:

a brush for contacting a moving conductive surface;

an electrical lead having a first end secured to the brush and a second end;

a nugget at the second end of the electrical lead, the nugget including a rear surface, a front surface opposite the rear surface, and first and second side surfaces extending between the front surface and the rear surface;

a resilient clip removably coupled to the nugget, the resilient clip contacting the front surface and facing the first and second side surfaces of the nugget; and

a receptacle having a cavity for removably receiving the nugget and the resilient clip therein;

wherein the resilient clip is elastically compressed in the cavity to press against the nugget and urge the rear surface of the nugget into direct contact with a surface of the receptacle partially defining the cavity;

wherein an electrical current pathway is provided from the brush through the electrical lead to the nugget, and from the rear surface of the nugget to the surface of the receptacle.

26. The assembly of claim **25**, wherein the resilient clip does not contact the rear surface of the nugget.

27. The assembly of claim **25**, wherein the nugget is formed by securing an end portion of the electrical lead in a channel of a U-shaped sleeve.

28. The assembly of claim **27**, wherein a first surface of the U-shaped sleeve defines the rear surface of the nugget.

29. The assembly of claim **28**, wherein the U-shaped sleeve includes first and second wing portions extending from a back portion of the U-shaped sleeve, wherein the resilient clip presses against an edge of the first wing portion and an edge of the second wing portion.

30. The assembly of claim **29**, wherein the resilient clip includes tabs in interlocking engagement with notches formed in the first and second wing portions.

31. The assembly of claim **25**, wherein the front surface of the nugget includes first and second stepped edges and the resilient clip includes first and second arms contacting the first and second stepped edges of the front surface of the nugget.

32. The brush holder assembly of claim 13, wherein the nugget is a monolithic structure of the electrical lead.

33. The assembly of claim 13, wherein the nugget is a separately formed structure secured to filaments of the electrical lead.

34. The method of claim 20, wherein the second resilient clip is removably coupled to a shaped nugget secured to filaments of the electrical lead.

35. The assembly of claim 25, wherein the nugget is a monolithic structure of the electrical lead.

36. The assembly of claim 25, wherein the nugget is a separately formed structure secured to filaments of the electrical lead.

37. The brush holder assembly of claim 2, wherein the second end of the electrical lead includes a nugget.

38. The brush holder assembly of claim 37, wherein the nugget is a monolithic structure of the electrical lead.

39. The brush holder assembly of claim 37, wherein the nugget is a separately formed structure secured to filaments of the electrical lead.

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