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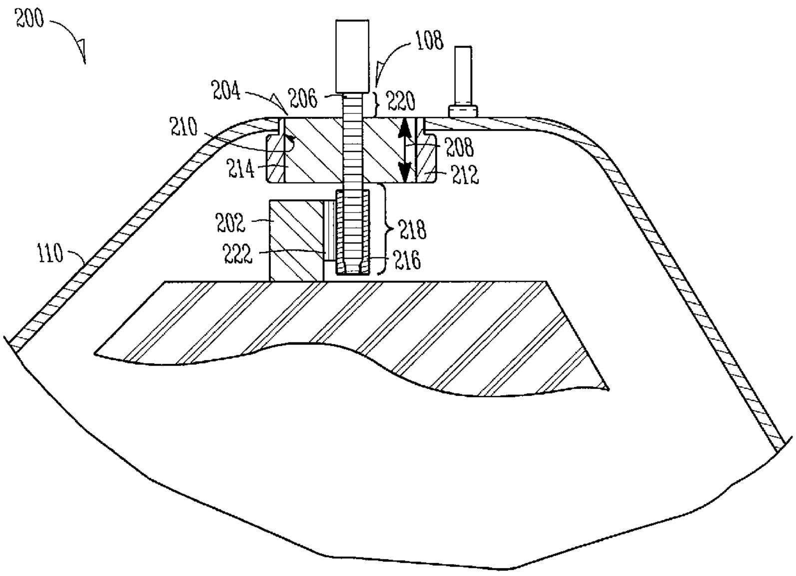
(54) Title: FEEDTHROUGH ASSEMBLY INCLUDING SLEEVE



(57) Abstract: A feedthrough assembly is disposable in an aperture of, for example, a power source encasement. In various examples, the feedthrough assembly comprises one or more of a ferrule, an insulator, a terminal conductor, and a sleeve. In various examples, a portion of the terminal conductor extends through the ferrule thereby creating a portion internal to and a portion external to the encasement. The insulator is disposed within the ferrule and is sealably engaged with the terminal conductor portion extending through the ferrule. The sleeve is disposed over the internal portion of the terminal conductor and coupled thereto. In one example, the sleeve includes at least one notch, which may be used to weld or solder the sleeve to the terminal conductor. In another example, the sleeve includes a longitudinally extending void, which may be used to crimp the sleeve to the terminal conductor.

WO 2007/109649 A2

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

FEEDTHROUGH ASSEMBLY INCLUDING SLEEVE

CLAIM OF PRIORITY

Benefit of priority is hereby claimed to U.S. Patent Application Serial Number 11/277,213, filed on March 22, 2006, which application is herein incorporated by reference.

TECHNICAL FIELD

This patent document pertains generally to electrical feedthrough assemblies for use in medical devices, and more particularly, but not by way of limitation, to feedthrough assemblies including a sleeve and methods related thereto.

BACKGROUND

Numerous applications involve penetrating a sealed encasement (e.g., a sealed container) so-as-to provide electrical access to or from electrical components enclosed within. One such application involves body implantable medical devices (referred to as "IMDs"), such as pulse generators or cardiac function management devices, for the treatment of bradycardia, tachyarrhythmia, or muscle or nerve stimulation. One such example involves providing electrical access to and from a power source (e.g., a battery) of an IMD.

Electrical feedthrough assemblies provide a conductive path extending between the interior of the sealed encasement and a location outside the encasement. Typically, the conductive path comprises a conductive pin or other type of terminal conductor that is electrically insulated from the encasement. In addition, feedthrough assemblies may include a ferrule and an insulative material for positioning and insulating the pin within the ferrule. In the battery power source example, a conductive connection member is often directly coupled to an internal portion of the conductive pin (i.e., a portion located within the battery encasement) on a first end and coupled to an anode or cathode of the battery on a second end.

When used in IMDs, feedthrough assemblies need to provide years of reliable service since maintenance or repair possibilities for the devices are extremely limited and costly. Moreover, failures of the feedthrough assembly or components thereof can have catastrophic consequences as extreme as death for a subject reliant on the IMD. Therefore, feedthrough assemblies need to comprise, among other things, highly reliable components and secure interconnections.

OVERVIEW

A feedthrough assembly is disposable in an aperture of, for example, a power source encasement. In various examples, the feedthrough assembly comprises one or more of a ferrule, an insulator, a terminal conductor, and a sleeve. In various examples, a portion of the terminal conductor extends through the ferrule thereby creating a portion internal to and a portion external to the encasement. The insulator is disposed within the ferrule and is sealably engaged with the terminal conductor portion extending through the ferrule. The sleeve is disposed over the internal portion of the terminal conductor and coupled thereto. In one example, the sleeve includes at least one notch, which may be used to weld or solder the sleeve to the terminal conductor. In another example, the sleeve includes a longitudinally extending void, which may be used to crimp the sleeve to the terminal conductor. In a further example, the sleeve includes at least one of a swage projection, a flat coupling portion, or an introductory opening.

In Example 1, a feedthrough assembly for use with an encasement having at least one encasement aperture comprises an insulator disposed within a portion of the at least one encasement aperture; a terminal conductor extending through the insulator, the terminal conductor having an internal portion disposed within the encasement and an external portion disposed outside of the encasement, the internal and external portions separated by a terminal conductor portion positioned within the insulator; and a sleeve extending from a sleeve first end to a sleeve second end, the sleeve disposed, at least in part, over the internal portion of the terminal conductor.

In Example 2, the feedthrough assembly of Example 1 optionally comprises a ferrule in contact with the encasement on an outer ferrule surface and in contact with the insulator on an inner ferrule surface.

In Example 3, the feedthrough assembly of at least one of Examples 1 or 2 is optionally configured such that the sleeve includes at least one notch on one or both of the sleeve first end or the sleeve second end.

In Example 4, the feedthrough assembly of Example 3 optionally comprises a weld or a solder securing the sleeve to an outer surface of the terminal conductor; and is optionally configured such that the weld or the solder is disposed adjacent the at least one notch.

In Example 5, the feedthrough assembly of at least one of Examples 1-4 is optionally configured such that the sleeve includes a longitudinally extending void.

In Example 6, the feedthrough assembly of Example 5 optionally comprises a crimp securing the sleeve to an outer surface of the terminal conductor, the crimp occurring by way of the longitudinally extending void.

In Example 7, the feedthrough assembly of at least one of Examples 1-6 is optionally configured such that the internal portion of the terminal conductor includes one or more groves extending inward from an outer surface thereof; and the sleeve is deformable into the one or more grooves.

In Example 8, the feedthrough assembly of at least one of Examples 1-7 is optionally configured such that an outer surface of the sleeve includes a substantially flat portion sized and shaped to receive a portion of a substantially flat conductive connection member.

In Example 9, the feedthrough assembly of at least one of Examples 1-8 is optionally configured such that the sleeve first end includes an introductory opening having a first diameter, the first diameter narrowing to a diameter larger than an outer diameter of the terminal conductor.

In Example 10, the feedthrough assembly of at least one of Examples 1-9 is optionally configured such that the insulator comprises at least one of a glass, a ceramic, a diamond, a ruby, zinc oxide, or a dielectric polymer.

In Example 11, the feedthrough assembly of at least one of Examples 1-10 is optionally configured such that the terminal conductor comprises molybdenum.

In Example 12, the feedthrough assembly of at least one of Examples 1-11 is optionally configured such that the sleeve comprises at least one of stainless steel, aluminum, or titanium.

In Example 13, the feedthrough assembly of at least one of Examples 1-12 is optionally used in combination with an electrical power source for providing electrical current to an implantable medical device.

In Example 14, the feedthrough assembly of Example 13 is optionally configured such that an outer surface of the sleeve is electrically coupled to one of a cathode assembly or an anode assembly of the electrical power source; and an inner surface of the sleeve is electrically coupled to the internal portion of the terminal conductor.

In Example 15, the feedthrough assembly of at least one of Examples 13 or 14 is optionally configured such that a first end of a conductive connection member is electrically coupled to the outer surface of the sleeve and a second end of the conductive connection member is electrically coupled to one of the anode assembly of the cathode assembly.

In Example 16, the feedthrough assembly of Example 15 is optionally configured such that the conductive connection member comprises stainless steel.

In Example 17, a method of manufacturing a feedthrough assembly comprises providing a ferrule configured to support an insulator and a terminal conductor, the ferrule including a ferrule aperture; inserting at least a portion of the terminal conductor through the ferrule aperture, including positioning an internal portion of the terminal conductor within an encasement; surrounding a portion of the terminal conductor disposed within the ferrule aperture with the insulator; inserting, at least in part, the internal portion of the terminal conductor into a sleeve; and electrically coupling the sleeve to the terminal conductor.

In Example 18, the method of Example 17 optionally comprises mounting the feedthrough assembly in an aperture of the encasement.

In Example 19, the method of at least one of Examples 17 or 18 is optionally configured such that electrically coupling the sleeve to the terminal conductor includes welding or soldering the sleeve to the terminal conductor.

In Example 20, the method of at least one of Examples 17-19 is optionally configured such that electrically coupling the sleeve to the terminal conductor includes crimping the sleeve to the terminal conductor.

In Example 21, the method of at least one of Examples 17-20 is optionally configured such that electrically coupling the sleeve to the terminal conductor includes swaging the sleeve to the terminal conductor.

In Example 22, the method of at least one of Examples 17-21 optionally comprises electrically coupling a first end of a conductive connection member to the sleeve and electrically coupling a second end of the conductive connection member to one of an anode assembly or a cathode assembly disposed within the encasement.

In Example 23, the method of at least one of Examples 17-22 is optionally configured such that inserting the terminal conductor into the sleeve includes guiding the terminal conductor into the sleeve using a tapered introductory cavity on a sleeve first end.

In Example 24, the method of at least one of Examples 17-23 is optionally configured such that surrounding the terminal conductor with the insulator includes sealably engaging the insulator with the terminal conductor.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, which are not necessarily drawn to scale, like numerals describe similar components throughout the several views. Like numerals having different letter suffixes represent different instances of similar components. The drawings illustrate generally, by way of example, but not by way of limitation, various embodiments discussed in the present document.

FIG. **1** illustrates a generalized isometric view of an implantable medical device.

FIG. **2** illustrates a cross-sectional view of a feedthrough assembly and an encasement along line **2-2** of FIG. **1**.

FIG. **3A** illustrates an isometric view of a sleeve for use in a feedthrough assembly.

FIG. **3B** illustrates a longitudinal cross-sectional view of the sleeve of FIG. **3A** along line **3B-3B**.

FIG. **3C**	illustrates a transverse cross-sectional view of the sleeve of FIG. **3A** along line **3C-3C**.
FIG. **4A**	illustrates an isometric view of another sleeve for use in a feedthrough assembly.
FIG. **4B**	illustrates a longitudinal cross-sectional view of the sleeve of FIG. **4A** along line **4B-4B**.
FIG. **4C**	illustrates a transverse cross-sectional view of the sleeve of FIG. **4A** along line **4C-4C**.
FIG. **5A**	illustrates an isometric view of another sleeve for use in a feedthrough assembly and a portion of a terminal conductor for coupling therewith.
FIG. **5B**	illustrates a longitudinal cross-sectional view of the sleeve of FIG. **5A** along line **5B-5B**.
FIG. **5C**	illustrates a transverse cross-sectional view of the sleeve of FIG. **5A** along line **5C-5C**.
FIG. **6A**	illustrates an isometric view of another sleeve for use in a feedthrough assembly and a portion of a conductive connection member coupled therewith.
FIG. **6B**	illustrates a longitudinal cross-sectional view of the sleeve and the conductive connection member of FIG. **6A** along line **6B-6B**.
FIG. **6C**	illustrates a transverse cross-sectional view of the sleeve and the conductive connection member of FIG. **6A** along line **6C-6C**.
FIG. **7A**	illustrates an isometric view of yet another sleeve for use in a feedthrough assembly.
FIG. **7B**	illustrates a longitudinal cross-sectional view along line **7B-7B** of FIG. **7A**.
FIG. **8**	illustrates a method of fabricating a feedthrough assembly comprising a sleeve.

DETAILED DESCRIPTION

The following detailed description includes references to the accompanying drawings, which form a part of the detailed description. The drawings show, by way of illustration, specific embodiments in which the present assemblies and methods may be practiced. These embodiments, which are also referred to herein as "examples," are described in enough detail to enable those skilled in the art to practice the present assemblies and methods. The embodiments may be combined, other embodiments may be utilized, or structural, logical and electrical changes may be made. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present assemblies and methods are defined by the appended claims.

In this document the terms "a" or "an" are used to include one or more than one; the term "or" is used to refer to a nonexclusive or unless otherwise indicated; and the term "subject" is used to include the term "patient." In addition, it is to be understood that the phraseology or terminology employed herein, and not otherwise defined, is for the purpose of description only and not of limitation.

Introduction

The present assemblies and methods provide, among other things, a conductive path extending between the interior of an encasement, such as an IMD power source encasement, and a location outside the encasement via a feedthrough assembly including a sleeve. Use of the sleeve increases the connection strength between components of the feedthrough assembly (e.g., a terminal conductor and a conductive connection member). This enhances the reliability of the feedthrough assembly and IMDs employing the same. In addition, the sleeve facilitates manufacturability of feedthrough assembly connections (e.g., by providing a larger connection surface area for welding, soldering, or brazing a conductive connection member to a terminal conductor) thereby reducing manufacturing costs. These and other aspects, advantages, and features of the present assemblies and methods will become apparent from a consideration of the following description and associated drawings.

Examples

In FIG. **1**, an example of a generic IMD **100** is illustrated. In this example, the IMD **100** includes a power source section **102**, an electronics section **104**, a capacitor section **106**, and one or more feedthrough assemblies **108**. The "IMD" will typically include, among other things, cardiac function management (referred to as "CFM") systems such as pacemakers, cardioverters/defibrillators, paces/defibrillators, biventricular or other multi-site resynchronization or coordination devices such as cardiac resynchronization therapy (referred to as "CRT") devices, or drug delivery systems.

The power source section **102** may include, but is not limited to, an electrochemical cell, an electrolytic or other capacitor, or a battery. In one example, the power source section **102** comprises a battery having an anode or a cathode **202** terminal (FIG. **2**) and is enclosed by a encasement **110**, such as a can or other container. In the example of FIG. **2**, the encasement **110** includes at least one encasement aperture **204** into which the one or more feedthrough assemblies **108** are mounted. As discussed above, each feedthrough assembly **108** penetrates the otherwise sealed encasement **110**, such as to provide electrical access to or from one or more electrical components enclosed therewithin (e.g., the anode or the cathode terminal **202**).

Notably, FIG. **1** illustrates one example of various sections and assemblies of an IMD **100**. The power source section **102**, the electronics section **104**, the capacitor section **106**, and the one or more feedthrough assemblies **108** are illustrated separately for conceptual clarity; however, such sections and assemblies may be further separated or need not be separately embodied.

FIG. **2** illustrates a cross-sectional view **200**, such as along line **2-2** of FIG. **1**, of an example of a single-terminal feedthrough assembly **108** and a battery or other encasement **110** into which the feedthrough assembly **108** provides access to or from. In this example, the encasement **110** includes at least one aperture **204** into which the feedthrough assembly **108** is mounted. In various examples, the feedthrough assembly **108** is coupled to a wall surface of the aperture **204**, such as via laser or resistance welding, soldering, brazing, gluing, or any other suitable connection technique known in the art.

In the example of FIG. **2**, but as may vary, the feedthrough assembly **108** includes a ferrule **212**, an insulator member or body **214** contacting the ferrule **212**, a terminal conductor (e.g., a conductor pin) **206** with a length **208** portion extending through an opening **210** in the ferrule **212**, and a sleeve **216**. By identifying a portion of its length **208** as extending through the opening **210**, the terminal conductor **206** may be conceptualized as having an internal portion **218** extending into the interior of the encasement **110** and an external portion **220** extending out of the encasement **110**. Using one or more of a variety of techniques, as further discussed below, the sleeve **216** is affixed to the internal portion **218** of the terminal conductor **206**, such as to increase the strength or reliability of one or more connections made thereto, such as by a conductive connection member **222**.

In the example of FIG. 2, the insulator member or body **214** surrounds at least a portion of the length **208** of the terminal conductor **206** extending through the opening **210**. In one example, the insulator **214** comprises a glass such as sapphire; however, the present assemblies and methods are not so limited. The insulator member or body **214** can be made of any suitable ceramic-containing material or other electrically-insulative material such as diamond, ruby, zinc oxide, or even one or more high dielectric polymers such as one or more polyimides. Among other utilities, the insulator member or body **214** prevents a short circuit from occurring between the terminal conductor **206** and the ferrule **212** or the encasement **110**.

In order to ensure a tight seal between the insulator member or body **214** and the walls of the encasement **110** or the encasement aperture **204**, the ferrule **212** may be disposed as a sleeve therebetween. Among other things, the ferrule **212** provides a support for the insulator **214** and the terminal conductor **206** or a means for mounting the feedthrough assembly **108** in the encasement **110**, such as via welding, soldering, brazing, gluing, or any other suitable connection. The ferrule **212** is typically annular; however, the ferrule **212** may have any other configuration suitable for use with the encasement **110**. The ferrule **212** may comprise any material or combination of materials known in the art to be suitable for providing support for the insulator **214** and the terminal conductor

206 or providing a means for mounting the feedthrough assembly **108** in the encasement **110**.

Electrical feedthrough assemblies **108** that are used in, for example, body IMDs may potentially come in contact with bodily fluids. Thus, it is desirable that components of the feedthrough assembly **108**, such as the terminal conductor **206**, comprise bio-stable, non-corrosive materials. The terminal conductor **206** may comprise one or more of molybdenum, titanium, tantalum, platinum, iridium, zirconium, aluminum, stainless steel, nitrides of such metals, alloys of such metals, or one or more other bio-stable metals. In one example, the terminal conductor **206** comprises molybdenum, which has a coefficient of thermal expansion (referred to as "CTE") similar to the CTE of an insulator **214** comprising glass. By substantially matching the CTE of the insulator **214** with the CTE of the terminal conductor **206**, the insulator **214** (e.g., glass) does not crack when it cools from an elevated temperature to a lower temperature.

As discussed above, the feedthrough assembly **108** comprises a sleeve **216** coupled to the internal portion **218** of the terminal conductor **206**. The sleeve **216** allows for, among other things, a more secure connection to be established between the terminal conductor **206** and one or more components within the encasement **110**, such as an anode or cathode **202** of a battery. In particular, the sleeve **216** allows for a more secure connection to be established between the terminal conductor **206** and a conductive connection member **222** (e.g., a conductive ribbon), the latter of which may be used to link the terminal conductor **206** to the anode or cathode **202** of the battery. Although not shown, the anode and cathode **202** are typically separated by a separator, such as an ion-permeable separator.

Experimental tests have shown that pull-strengths of the connection between the terminal conductor **206** and the conductive connection member **222** greatly increase when a sleeve **216** is used in the connection scheme. For example, according to one test, the pull-strength of a terminal conductor **206**/conductive connection member **222** connection using a sleeve **216** was found to be more than double that which was found when the sleeve **216** was not used in the connection (i.e., when the conductive connection member **222** was coupled directly to an outer surface of the terminal conductor **206**). Besides increased pull-strength, use of the sleeve **216** may also advantageously help avoid connection failure or improve the mode by which connection failure occurs. As one example, use of the sleeve **216** allows for force distribution on the terminal conductor **206** in a manner that improves the fatigue resistance of the connection (i.e., the connection between the terminal conductor **206** and the conductive connection member **222**).

Yet another advantage of the sleeve **216** is that it can effectively change the material compositions of the feedthrough assembly **108** components to be coupled. As one example, if the terminal conductor **206** is composed of a first material and the conductive connection member **222** is composed of a second material that is not easily weldable or otherwise couplable to the first material, a sleeve **216** composed of a material more compatible with the second material may be crimped or otherwise attached to the terminal conductor **206**, thereby effectively changing the material composition of the terminal conductor **206** as far as the conductive connection member **222** is concerned to that of the sleeve **216**. The sleeve **216** may comprise stainless steel, aluminum, titanium, or any other material compatible with the particular battery chemistry.

FIGS. **3A-3C**, **4A-4C**, **5A-5C**, **6A-6C**, and **7A-7B** illustrate various examples of sleeve **216** structures that may be used, such as to facilitate or strengthen a connection between a terminal conductor **206** (FIG. **2**) and a conductive connection member **222** (FIG. **2**). The sleeve **216** may be affixed to the terminal conductor **206**, such as via welding (see FIGS. **3A-3C**), soldering (see FIGS. **3A-3C**), brazing (see FIGS. **3A-3C**), crimping (see FIGS. **4A-4C**), or swaging (see FIGS. **5A-5C**) techniques. In certain examples, the sleeve **216** includes one or more notches **302** (FIG. **3**), longitudinally-extending notches or voids **402** (FIG. **4**), swage projections **502** (FIG. **5**), flat portions **602** (FIG. **6**), or introductory openings **702** (FIG. **7**), such as to facilitate insertion of the terminal conductor **206** within the sleeve **216**, attachment of the sleeve **216** and the terminal conductor **206**, or positioning of the sleeve **216** with respect to the terminal conductor **206**.

The sleeve **216** need not be specifically extruded during manufacture, but rather can be stock (commonly referred to as "off-the-shelf") tube or pipe, thereby reducing manufacturing costs in comparison with specifically extruded sleeves. In varying examples, a length **304** of the sleeve **216** is sufficient to surround at least a portion of an internal portion **218** (FIG. **2**) of the terminal conductor **206**. In one example, the length **304** of sleeve **216** is about 0.055 inches. In another example, the length **304** of the sleeve **216** is about 0.070 inches. In varying examples, an inner diameter **306** of the sleeve **216** is slightly larger than an outer diameter of the terminal conductor **206**. In one example, the inner diameter **306** of the sleeve **216** is about 0.016 inches while an outer diameter **308** of the sleeve **216** is about 0.028 inches.

The example sleeve **216** shown in FIGS. **3A-3C** includes one or more notches **302**, which may be used for the positioning of the sleeve **216** relative to the terminal conductor **206** or for connection between such components. In one example, a notch **302** is used to laser or resistance weld, solder, or braze the sleeve **216** to the terminal conductor **206**. In example shown, the notch **302** extends inward from a sleeve end face **310** and has a size of about 0.016 inches x about 0.016 inches. In another example, the notch **302** has a size of about 0.012 inches x about 0.012 inches. Similarly, the sleeve **216** may include at least one notch **302** extending inward from each sleeve end face **310**.

The example sleeve **216** shown in FIGS. **4A-4C** includes a longitudinally-extending void **402**, which may be used to couple the sleeve **216** to the terminal conductor **206**, such as via crimping forces. The longitudinally-extending void **402** allows the sleeve crimp faces **404** to move toward one another when a crimping force is applied to an outer surface of the sleeve **216**. As the crimp faces **404** move closer to one another, the inner diameter **306** of the sleeve **216** is effectively reduced thereby increasing press-fitting forces experienced by an outer surface of the terminal conductor **206** and the inner surface of sleeve **216**.

FIGS. **5A-5C** illustrate an example sleeve **216** including one or more swage projections **502** and an internal portion **218** (FIG. **2**) of a terminal conductor **206**. In this example, the internal portion **218** includes one or more grooves **504** into which portions of the sleeve **216** may be deformed. In one example, after the sleeve **216** is disposed over the internal portion **218**, the sleeve may be deformed, such as by rotary swaging (i.e., a metal forming process for the diametrical reduction of annular members, such as tubes). In this example, rotary swaging of the sleeve **216** provides an inward force on the swage projections **502** causing the shape of the sleeve **216** to deform into the grooves **504**. As a result, the sleeve **216** becomes affixed to the terminal conductor **206**.

FIGS. **6A-6C** illustrate an example sleeve **216** including a flat portion **602** extending the entire or a portion of the length **304** of the sleeve **216**. Coupled to the flat portion **602** is a first end of a conductive connection member **222**. An opposing second end of the connection member **222** may be attached to, for example, an anode or cathode **202** of a battery. In this example, the conductive connection member **222** comprises a stainless steel or other conductive ribbon. The flat portion **602** permits good surface contact with the conductive ribbon **222,** thereby allowing a solid weld or other coupling therebetween.

The sleeve **216** in the example of FIGS. **7A-7B** includes an introductory opening **702**, which facilitates the insertion of a terminal conductor **206** (FIG. **2**) into the sleeve **216**. As shown in the example of FIG. **7B**, an opening diameter **704** of the introductory opening **702** is greater than a diameter **506** (FIG. **5A**) of an internal portion **218** of the terminal conductor **206**. In this example, the introductory opening **702** continuously narrows or otherwise tapers to a diameter slightly larger than the diameter **506** but smaller than opening the diameter **704**, thereby guiding the terminal conductor **206** within the sleeve **216**.

FIG. **8** illustrates a method **800** of fabricating a feedthrough assembly including a sleeve. At **802**, a ferrule including a ferrule aperture is provided. At **804**, a portion of a terminal conductor (e.g., a terminal pin) is inserted through the ferrule aperture such that when the ferrule is mounted in an aperture of an encasement at **814**, one end of the terminal conductor extends into an interior of the encasement and makes contact with a desired portion of the contents thereof, and the other end extends exteriorly of the encasement. At **806**, a portion of the terminal conductor disposed within the ferrule aperture is surrounded by an insulator member or body (e.g., glass). In one example, surrounding the terminal conductor with the insulator includes sealably engaging the insulator with the terminal conductor to prevent any leakage, such as electrolyte or other fluid leakage, between such components.

At **808**, a sleeve for attachment to the internal portion of the terminal conductor is selected. The sleeve may, but need not, contain notches, windows, chamfers, terminal conductor guidance cavities, or other voids or configurations, such as to facilitate overlapping, positioning, or attaching of the sleeve on or to the terminal conductor. At **810**, the internal portion of the terminal conductor is inserted into the selected sleeve. In one example, insertion of the terminal conductor into the sleeve includes using a tapered introductory cavity (e.g., a funnel-shaped configuration) integrated with a sleeve first end.

At **812**, the selected sleeve is electrically and mechanically connected to the internal portion of the terminal conductor. In one example, connection of the sleeve to the terminal conductor includes laser or resistance welding, soldering, or brazing of the sleeve to the terminal conductor. In another example, connection of the sleeve to the terminal conductor includes crimping of the sleeve onto the terminal conductor. In yet another example, connection of the sleeve to the terminal conductor includes deformation (e.g., via rotary swaging) of the sleeve into one or more groove of the terminal conductor. In a further example, connection of the sleeve onto the terminal conductor includes heating the sleeve such that it expands, then placing the sleeve onto the terminal conductor, and finally allowing the sleeve to compressively cool onto the terminal conductor.

As discussed above, the feedthrough assembly is mountable in an aperture of an encasement, such as an electrical power source encasement, which occurs at **814**. In one example, the feedthrough assembly is mounted in the aperture via welding, soldering, brazing, or through the use of an adhesive. At **816**, a first end of the conductive connection member is coupled to the sleeve and a second end of the connection member is coupled to an anode or a cathode of an electrical power source battery. In one example, the conductive connection member includes a stainless steel ribbon which is welded to an internal portion of the sleeve on a first end and to the anode or cathode on a second end.

Conclusion

Feedthrough assemblies and methods for their manufacture are provided herein. Among other things, the present assemblies and methods provide a feedthrough assembly including a connection-facilitating sleeve. The sleeve increases the strength and fatigue resistance of interconnections between feedthrough components (e.g., the terminal conductor and the conductive connection member). This enhances reliability of the feedthrough assembly and IMDs employing the same. In addition, use of the sleeve improves the manufacturability of feedthrough assemblies, as a greater, more robust surface area is available for electrical coupling (e.g., welding, soldering, or brazing) between the conductive terminal and the conductive connection member.

The present assemblies and methods are not limited to feedthroughs for batteries, but extend to other IMD or like applications where it is desired to penetrate a sealed encasement, such as to provide electrical access to or from electrical components enclosed within. It will also be appreciated by those skilled in the art that while a number of specific dimensions or method orders are discussed above, the present assemblies can be made of any size (e.g., lengths, widths, or diameters) and may be fabricated in method orders other than those discussed.

It is to be understood that the above description is intended to be illustrative, and not restrictive. For example, the above-described embodiments or features thereof may be used in combination with each other. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the present assemblies and methods should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms “including” and “in which” are used as the plain-English equivalents of the respective terms “comprising” and “wherein.” Also, in the following claims, the terms “including” and “comprising” are open-ended, that is, a system, device, article, or process that includes elements in addition to those listed after such a term in a claim are still deemed to fall within the scope of that claim. Moreover, in the following claims, the terms “first,” “second,” and “third,” etc. are used merely as labels, and are not intended to impose numerical requirements on their objects.

The Abstract of the Disclosure is provided to comply with 37 C.F.R. §1.72(b), requiring an abstract that will allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims.

WHAT IS CLAIMED IS:

1. A feedthrough assembly for use with an encasement having at least one encasement aperture, the feedthrough assembly comprising:

an insulator disposed within a portion of the at least one encasement aperture;

a terminal conductor extending through the insulator, the terminal conductor having an internal portion disposed within the encasement and an external portion disposed outside of the encasement, the internal and external portions separated by a terminal conductor portion positioned within the insulator; and

a sleeve extending from a sleeve first end to a sleeve second end, the sleeve disposed, at least in part, over the internal portion of the terminal conductor.

2. The feedthrough assembly of claim 1, comprising a ferrule in contact with the encasement on an outer ferrule surface and in contact with the insulator on an inner ferrule surface.

3. The feedthrough assembly of claims 1 or 2, wherein the sleeve includes at least one notch on one or both of the sleeve first end or the sleeve second end.

4. The feedthrough assembly of claim 3, comprising a weld or a solder securing the sleeve to an outer surface of the terminal conductor; and

wherein the weld or the solder is disposed adjacent the at least one notch.

5. The feedthrough assembly of any of claims 1-4, wherein the sleeve includes a longitudinally extending void.

6. The feedthrough assembly of claim 5, comprising a crimp securing the sleeve to an outer surface of the terminal conductor, the crimp occurring by way of the longitudinally extending void.

7. The feedthrough assembly of any of claims 1-6, wherein the internal portion of the terminal conductor includes one or more groves extending inward from an outer surface thereof; and

wherein the sleeve is deformable into the one or more grooves.

8. The feedthrough assembly of any of claims 1-7, wherein an outer surface of the sleeve includes a substantially flat portion sized and shaped to receive a portion of a substantially flat conductive connection member.

9. The feedthrough assembly of any of claims 1-8, wherein the sleeve first end includes an introductory opening having a first diameter, the first diameter narrowing to a diameter larger than an outer diameter of the terminal conductor.

10. The feedthrough assembly of any of claims 1-9, wherein the insulator comprises at least one of a glass, a ceramic, a diamond, a ruby, zinc oxide, or a dielectric polymer.

11. The feedthrough assembly of any of claims 1-10, wherein the terminal conductor comprises molybdenum.

12. The feedthrough assembly of any of claims 1-11, wherein the sleeve comprises at least one of stainless steel, aluminum, or titanium.

13. The feedthrough assembly of any of claims 1-12 used in combination with an electrical power source for providing electrical current to an implantable medical device.

14. The feedthrough assembly of claim 13, wherein an outer surface of the sleeve is electrically coupled to one of a cathode assembly or an anode assembly of the electrical power source; and

wherein an inner surface of the sleeve is electrically coupled to the internal portion of the terminal conductor.

15. The feedthrough assembly of claims 13 or 14, wherein a first end of a conductive connection member is electrically coupled to the outer surface of the sleeve and a second end of the conductive connection member is electrically coupled to one of the anode assembly of the cathode assembly.

16. The feedthrough assembly of claim 15, wherein the conductive connection member comprises stainless steel.

17. A method of manufacturing a feedthrough assembly, the method comprising:

providing a ferrule configured to support an insulator and a terminal conductor, the ferrule including a ferrule aperture;

inserting at least a portion of the terminal conductor through the ferrule aperture, including positioning an internal portion of the terminal conductor within an encasement;

surrounding a portion of the terminal conductor disposed within the ferrule aperture with the insulator;

inserting, at least in part, the internal portion of the terminal conductor into a sleeve; and

electrically coupling the sleeve to the terminal conductor.

18. The method of claim 17, comprising mounting the feedthrough assembly in an aperture of the encasement.

19. The method of claims 17 or 18, wherein electrically coupling the sleeve to the terminal conductor includes welding or soldering the sleeve to the terminal conductor.

20. The method of any of claims 17-19, wherein electrically coupling the sleeve to the terminal conductor includes crimping the sleeve to the terminal conductor.

21. The method of any of claims 17-20, wherein electrically coupling the sleeve to the terminal conductor includes swaging the sleeve to the terminal conductor.

22. The method of any of claims 17-21, comprising electrically coupling a first end of a conductive connection member to the sleeve and electrically coupling a second end of the conductive connection member to one of an anode assembly or a cathode assembly disposed within the encasement.

23. The method of any of claims 17-22, wherein inserting the terminal conductor into the sleeve includes guiding the terminal conductor into the sleeve using a tapered introductory cavity on a sleeve first end.

24. The method of any of claims 17-23, wherein surrounding the terminal conductor with the insulator includes sealably engaging the insulator with the terminal conductor.

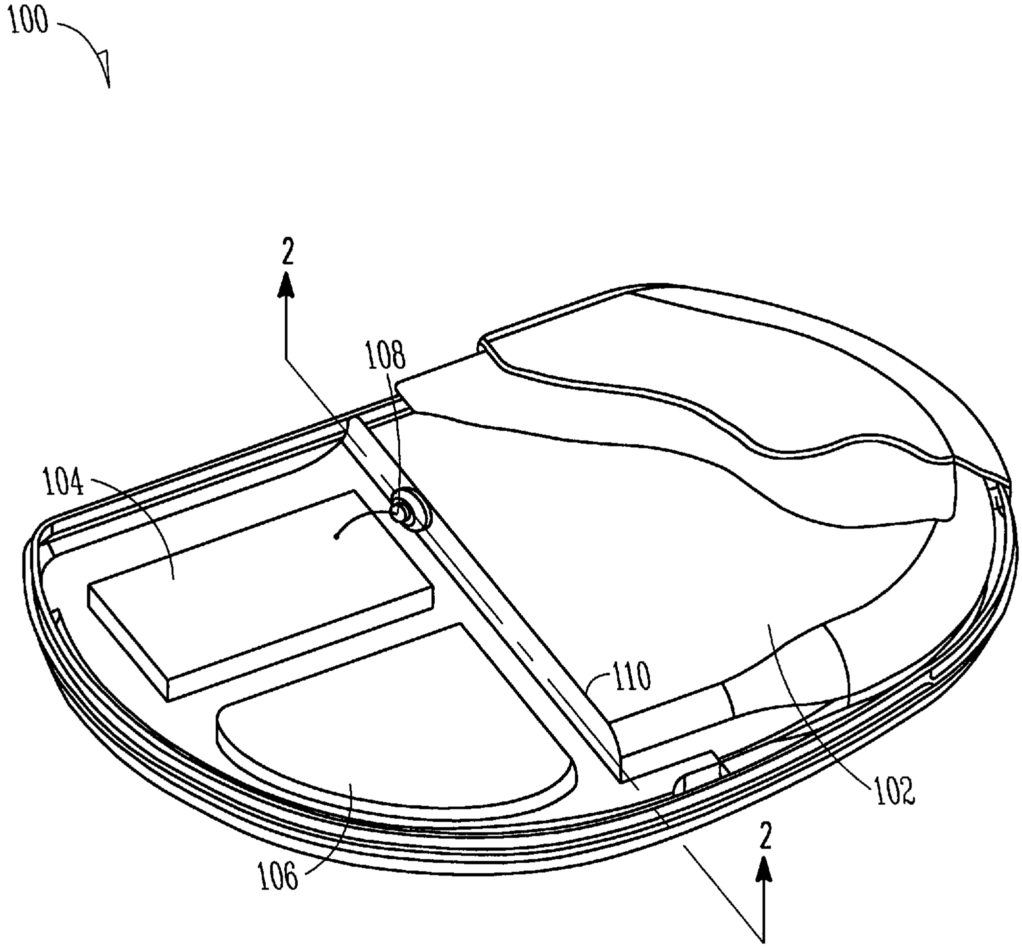


FIG. 1

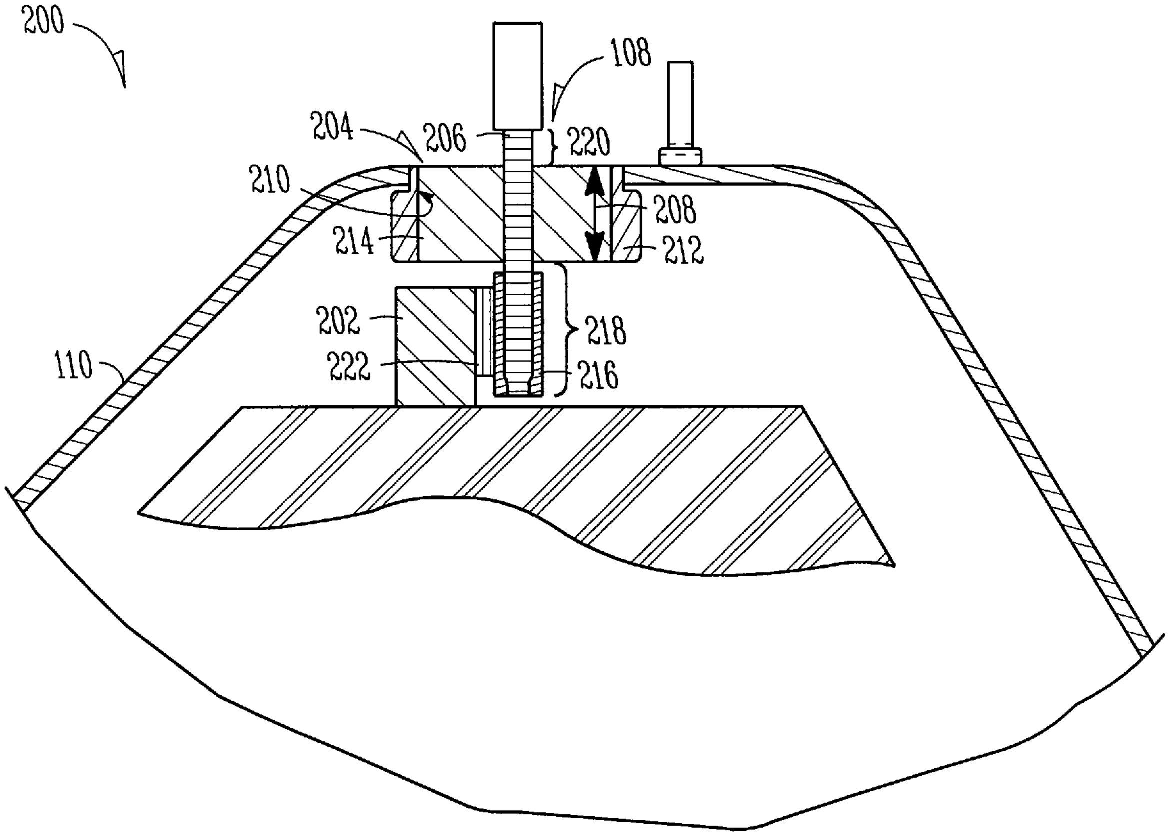


FIG. 2

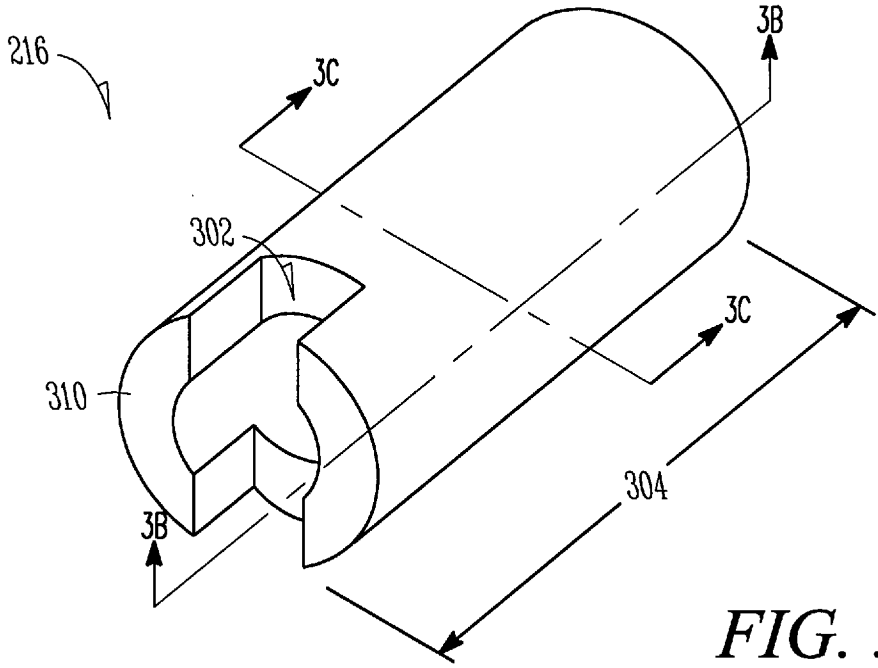


FIG. 3A

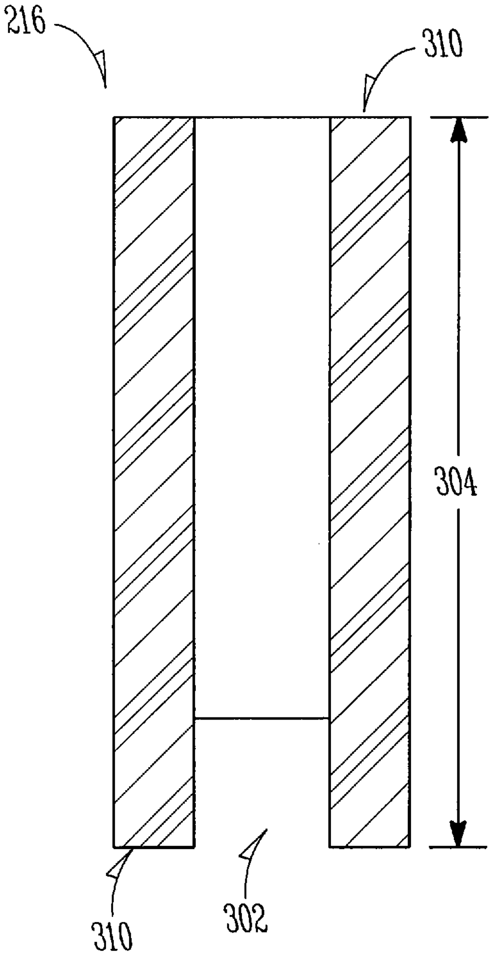


FIG. 3B

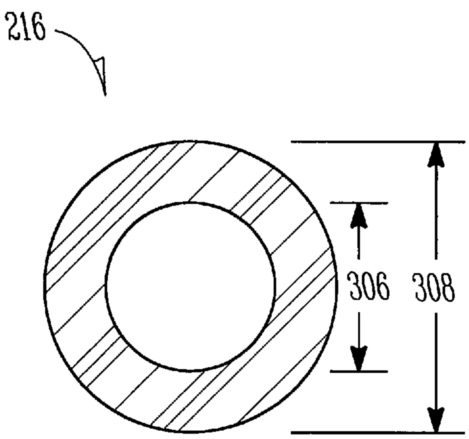


FIG. 3C

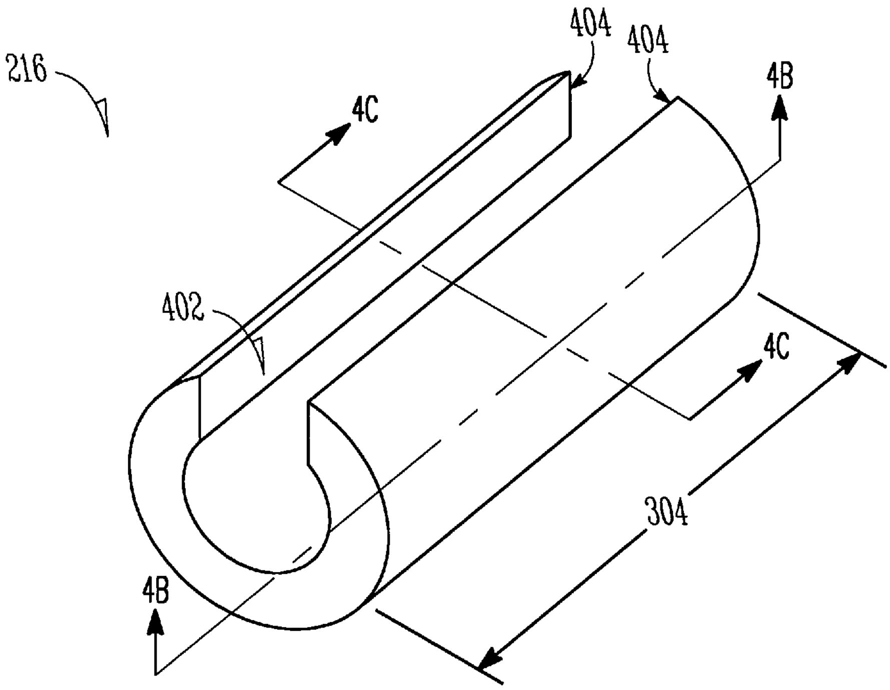


FIG. 4A

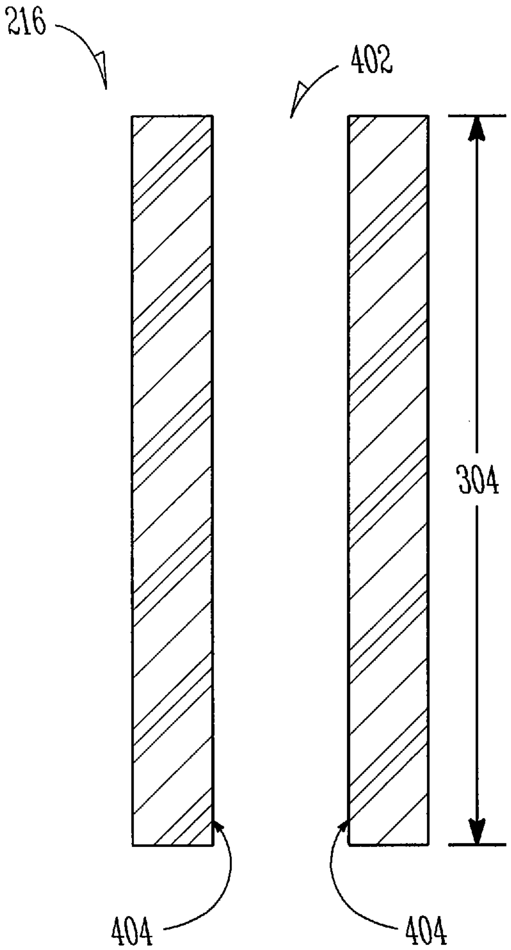


FIG. 4B

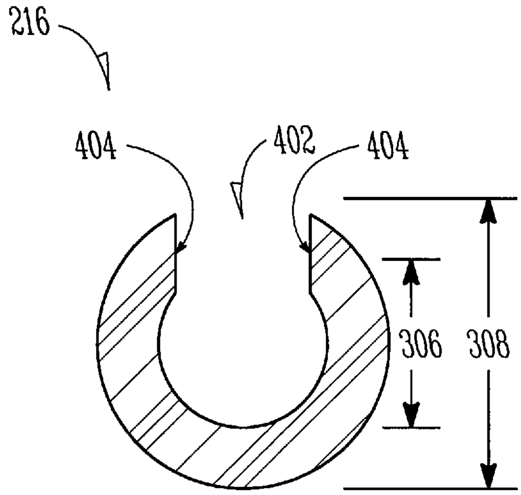


FIG. 4C

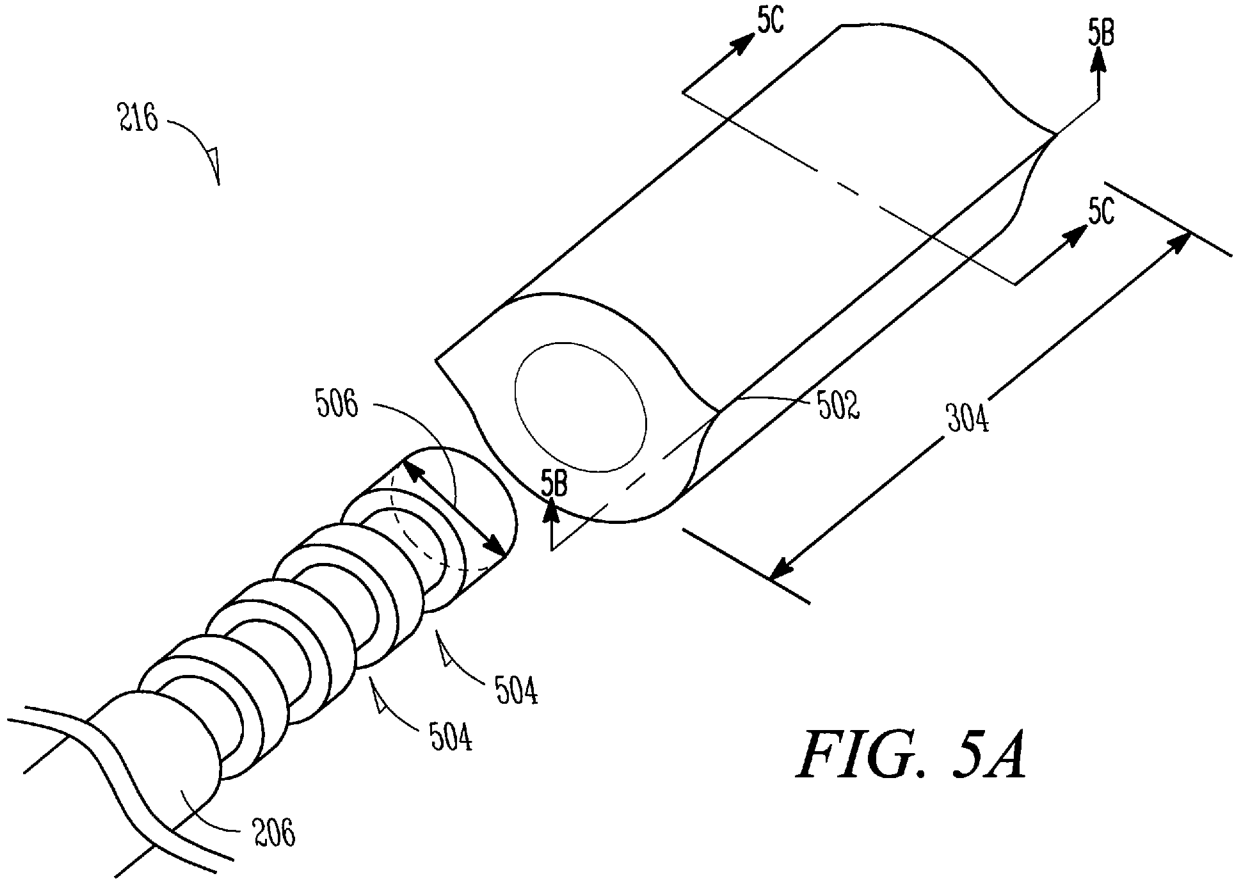


FIG. 5A

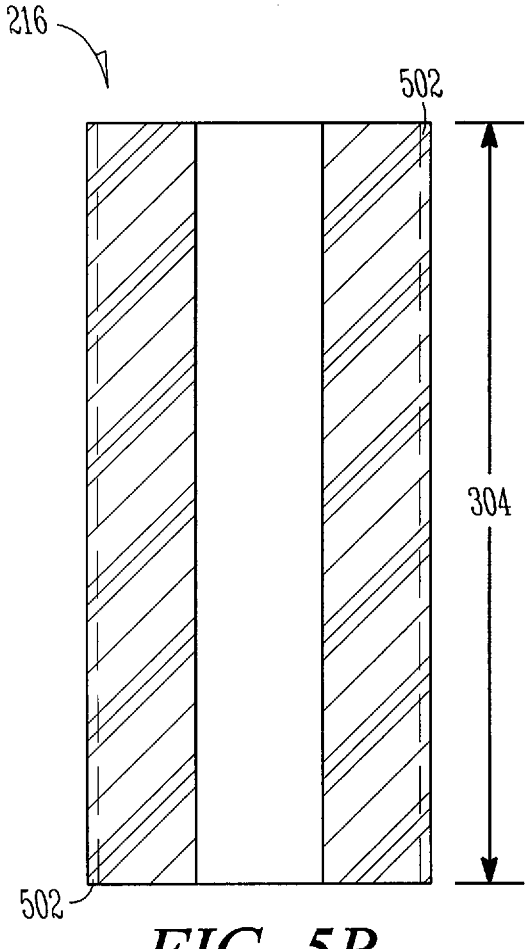


FIG. 5B

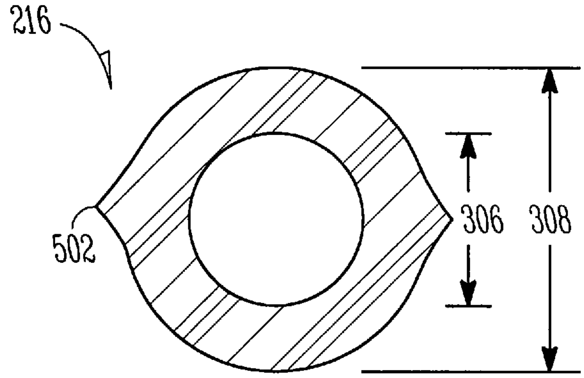


FIG. 5C

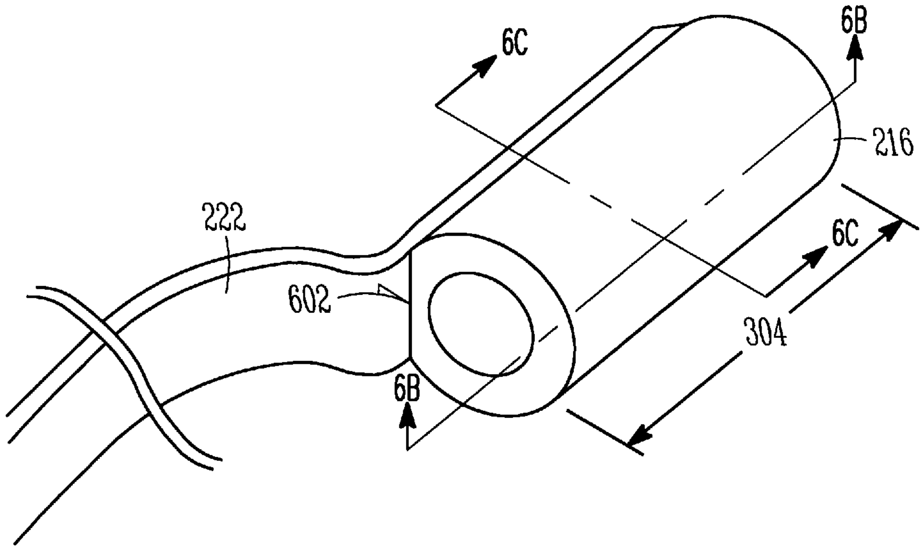


FIG. 6A

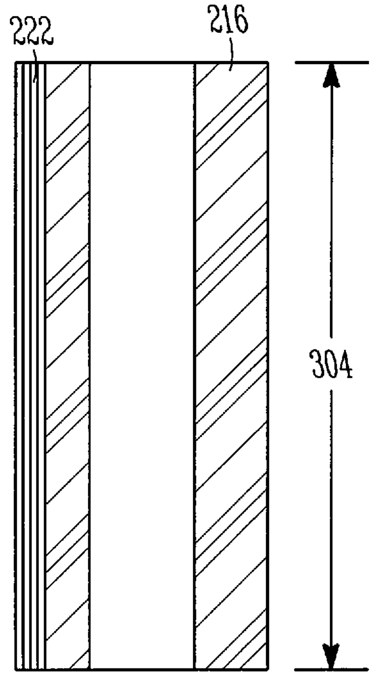


FIG. 6B

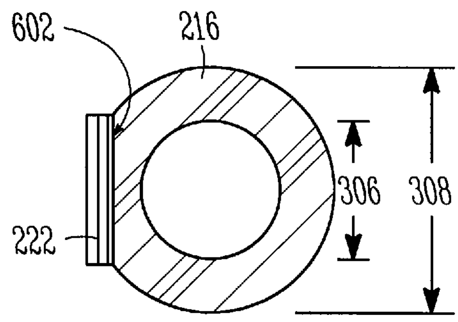


FIG. 6C

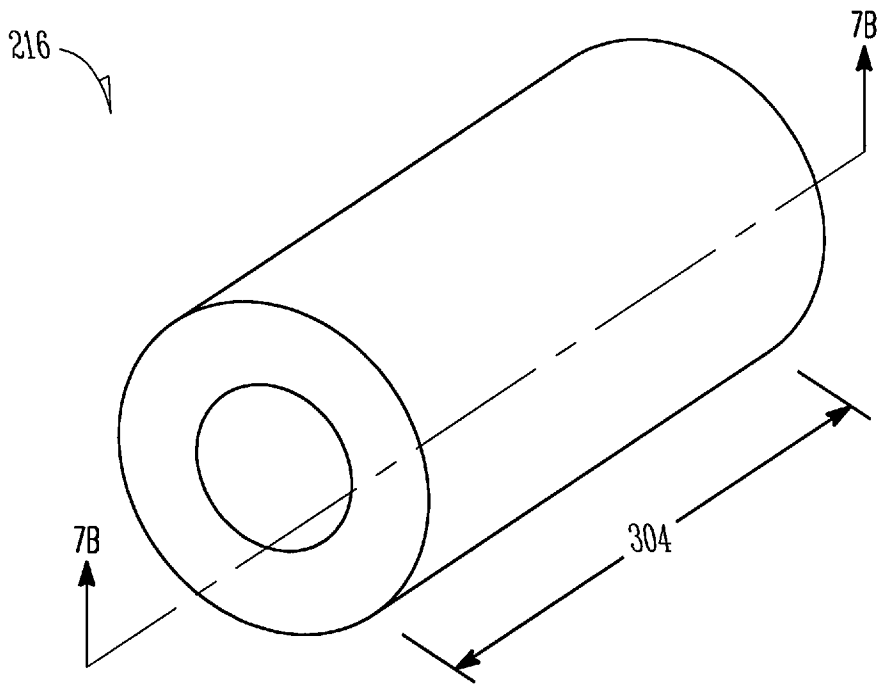


FIG. 7A

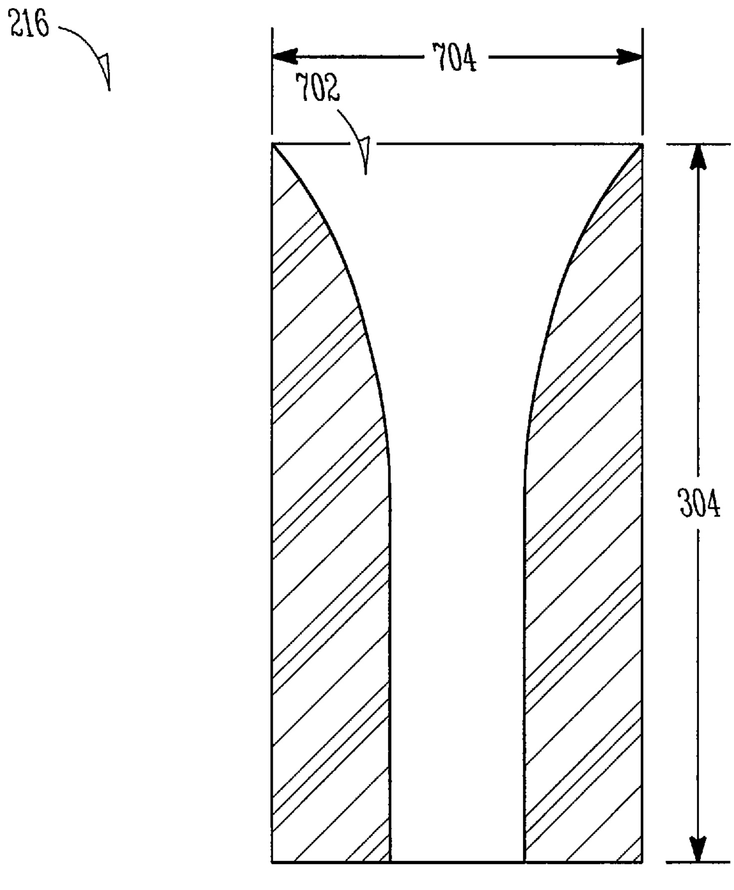


FIG. 7B

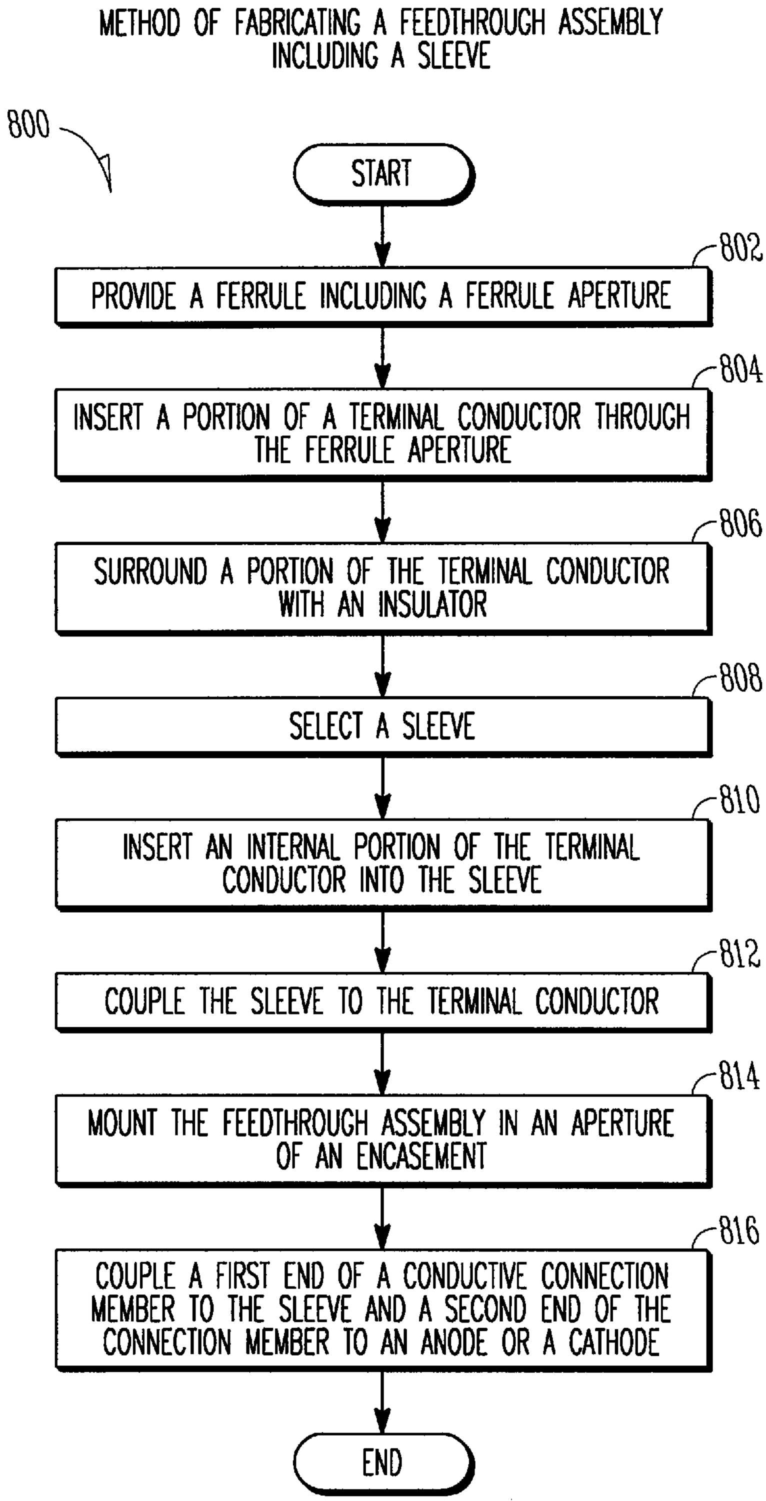

METHOD OF FABRICATING A FEEDTHROUGH ASSEMBLY INCLUDING A SLEEVE
800
START
802
PROVIDE A FERRULE INCLUDING A FERRULE APERTURE
804
INSERT A PORTION OF A TERMINAL CONDUCTOR THROUGH THE FERRULE APERTURE
806
SURROUND A PORTION OF THE TERMINAL CONDUCTOR WITH AN INSULATOR
808
SELECT A SLEEVE
810
INSERT AN INTERNAL PORTION OF THE TERMINAL CONDUCTOR INTO THE SLEEVE
812
COUPLE THE SLEEVE TO THE TERMINAL CONDUCTOR
814
MOUNT THE FEEDTHROUGH ASSEMBLY IN AN APERTURE OF AN ENCASEMENT
816
COUPLE A FIRST END OF A CONDUCTIVE CONNECTION MEMBER TO THE SLEEVE AND A SECOND END OF THE CONNECTION MEMBER TO AN ANODE OR A CATHODE
END

FIG. 8