(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 394 698 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
07.10.2015 Bulletin 2015/41

(51) Int Cl.:
A61N 1/375 *(2006.01)* ***H01G 4/35*** *(2006.01)*

(21) Application number: **11169172.1**

(22) Date of filing: **08.06.2011**

(54) Full perimeter laser beam button weld of dissimilar materials

Laserstrahlpunktschweißen über einen vollständigen Umfang ungleicher Materialien

Soudure de bouton de faisceau laser sur le périmètre entier de matériaux dissemblables

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **08.06.2010 US 352612 P**

(43) Date of publication of application:
14.12.2011 Bulletin 2011/50

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority from U.S. Provisional Patent Application Serial No. 61/352,612 filed June 8, 2010.

1. Field of the Invention

[0002] This invention relates generally to a hermetic feedthrough terminal pin assembly, preferably of the type incorporating a filter capacitor. More specifically, this invention relates to a method of welding two dissimilar metals into feedthrough filter capacitor assemblies, particularly of the type used in implantable medical devices such as cardiac pacemakers, cardioverter defibrillators, and the like, to decouple and shield internal electronic components of the medical device from undesirable electromagnetic interference (EMI) signals.

2. Prior Art

[0003] Feedthrough assemblies are generally well known in the art for use in connecting electrical signals through the housing or case of an electronic instrument. For example, in an implantable medical device, such as a cardiac pacemaker, defibrillator, or neurostimulator, the feedthrough assembly comprises one or more conductive terminal pins supported by an insulator structure for passage of electrical signals from the exterior to the interior of the medical device. The conductive terminals are fixed into place using a gold brazing process, which provides a hermetic seal between the pin and insulative material.

[0004] Since feedthrough assemblies such as these are implanted in human bodies, it is generally preferred that the materials used to construct such assemblies are biocompatible. These biocompatible materials, although commonly considered to be immune to the human body, generally have different material properties. These differing material properties such as melting temperature, thermal expansion, thermal conductivity and electrical conductivity make these materials diffult to join and construct into a feedthrough assembly.

[0005] Feedthrough assemblies generally comprise an insulative body, a supporting ferrule, and a plurality of electrically conductive feedthrough terminal pins that are hermetically sealed in the insulative body. In some cases, a capacitor is also incorporated into the assembly to provide protection from electromagnetic interference (EMI). With respect to the present invention, additional metallic terminal blocks, incorporated with a polymeric body, are integrated in the feedthrough assembly. Nevertheless, the electrically conductive feedthrough terminal pins are preferrably electrically connected to these metallic terminal blocks located adjacent the polymeric body.

[0006] Terminal pins have been composed of niobium and niobium alloys. Niobium and niobium alloys are biocompatible refractory metals that are cost effective. The niobium material provides good mechanical strength and electrical conduction, which adds to the durability and performance of the feedthrough. However the refractive nature of the niobium metal makes it a difficult material with which to join to other metals, particularly non-refractive metals such as nickel.

[0007] Traditional methods of joining dissimilar metals such as a refractive metal to a non-refractive metal, typically result in cracking of the joint. This is particularly the case when niobium and nickel are joined together. Such joint cracks tend to create pathways for the introduction of undesirable debris and contamination. Debris and contamination could enter the assembly and potentially affect the electrical performance of the feedthrough assembly and/or connected device. What is desired is a feedthrough assembly and method of assembly thereof that produces a crack free joining of dissimilar metals, for example of a refractive metal and a non-refractive metal, particularly the metals niobium and nickel.

[0008] In conjunction with the difficulties in joining dissimilar metals, other constraints from adjacent materials of the feedthrough assembly present additional difficulties that need to be overcome in constructing feedthrough assemblies. For example, the generally lower melting temperatures of adjacent polymeric bodies provide additional constraining parameters, particularly when they are located adjacent to where dissimilar metals are being joined together. The present invention addresses these problems as it relates to the construction of feedthrough assemblies. The present invention further provides an optimal construction and joining process thereof by which dissimilar metals are joined in the construction of feedthrough assemblies.

[0009] US 2005/0007718 describes an electromagnetic interference filter terminal assembly for active implantable medical devices which includes a structural pad in the form of a substrate or attached wire bond pad, for convenient attachment of wires from the circuitry inside the implantable medical device to the capacitor structure via thermal or ultrasonic bonding, soldering or the like while shielding the capacitor from forces applied to the assembly during attachment of the wires. This known feedthrough comprises an insulator, a terminal pin, a ferrule, a first braze material, a protective cap made of ceramic, and, a terminal block with a laser weld joining said terminal pin to said terminal block.

[0010] US 2006/0174463 describes a capacitor feedthrough assembly having an electrically conductive member dimensioned to extend at least partially through a feedthrough hole of a case of the capacitor, the conductive member having a passage therethrough.

[0011] US 4,678,868 describes a hermetic feedthrough consisting of a niobium electrical lead-in wire surrounded by an alumina insulator which is carried by a niobium ferrule, the feedthrough being particularly adapted for being welded to the titanium container of an implantable medical device.

SUMMARY OF THE INVENTION

[0012] The present invention is defined by the independent claims 1 and 8. Preferred embodiments are defined in the claims dependent thereon.

[0013] In a preferred form, a feedthrough filter capacitor assembly according to the present invention comprises an outer ferrule hermetically sealed to either an alumina insulator or fused glass dielectric material seated within the ferrule. The insulative material is also hermetically sealed to at least one terminal pin. That way, the feedthrough assembly prevents leakage of fluid, such as body fluid in a human implant application, past the hermetic seal at the insulator/ferrule and insulator/terminal pin interfaces.

[0014] According to the invention, the terminal pin of a feedthrough assembly, and preferably of the feedthrough filter capacitor assembly, is composed of a biocompatible refractive metal, such as niobium. The terminal pin can be a uniform wire-type structure of niobium or an alloy thereof. In that respect, niobium is a corrosion resistant material that provides a more cost effective terminal pin than other conventional metals, such as platinum or platinum-iridium terminal pins. Furthermore, terminal pins composed of niobium achieve the same benefits of biocompatibility, good mechanical strength, electrical conduction and a reliable hermetic feedthrough seal.

[0015] A plurality of terminal blocks are each preferably positioned in a slot atop a polymeric protective cap which preferably resides within the proximal region of the feedthrough assembly. The plurality of terminal blocks, preferably composed of an electrically conductive metal such as nickel, provide a preferred means of electrically attaching the feedthrough assembly to a medical device.

[0016] These terminal blocks provide a larger surface area with which to attach electrical connections between the feedthrough assembly and the medical device. The protective cap, preferably composed of a biocompatible polymeric material, electrically insulates each individual terminal block and protects the feedthrough assembly from possible mechanical damage.

[0017] The specific design parameters and material properties comprising the feedthrough assembly of the present invention present particular constraints regarding connection of the terminal pin to the terminal block. As such, the present invention relates to a feedthrough assembly and manufacturing process thereof that provides a robust crack free full perimeter joint about the terminal pin to effectively join the dissimilar metals of the terminal pin and terminal block. In addition, joining the terminal pin to the terminal block, without causing damage to the adjacent polymeric protective cap, is discussed.

[0018] These and other objects and advantages of the present invention will become increasingly more apparent by a reading of the following description in conjunction with the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 is a perspective view of a feedthrough filter capacitor assembly.

FIG. 2 is top view of the feedthrough filter capacitor assembly shown in FIG. 1.

FIG. 3 is cross sectional view of the filter capacitor assembly shown in FIG. 1.

FIG. 4 is a magnified perspective view of the filter capacitor assembly shown in FIG. 1.

FIG. 5 is a magnified top view showing an embodiment of one of the welds of the present invention.

FIG. 6 is an illustration of a nickel - niobium binary phase diagram.

FIG. 7 shows a cross-sectional illustration of a prior art weld.

FIG. 7A shows a cross-sectional micrograph image of a prior art weld.

FIG. 8 illustrates a cross-section of a preferred weld embodiment of the present invention.

FIG. 8A shows a cross-sectional micrograph image of a preferred weld embodiment of the present invention.

FIG. 9 illustrates a preferred embodiment of an assembly process of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] Referring now to the drawings, FIGS. 1, 3, and 9 show an internally grounded feedthrough capacitor assembly 10 comprising a feedthrough 12 supporting a discoidal filter capacitor 14, a protective cap 16, and a plurality of terminal blocks 18.

[0021] The feedthrough filter assembly 10 is useful with medical devices, preferably implantable devices such as pacemakers, cardiac defibrillators, cardioverter defibrillators, cochlear implants, neurostimulators, internal drug pumps, deep brain stimulators, hearing assist devices, incontinence devices, obesity treatment devices, Parkinson's disease therapy devices, bone growth stimulators, and the like. The feedthrough 12 portion of the assembly 10 includes terminal pins 20 that provide for coupling, transmitting and receiving electrical signals to and from a patient's heart, while hermetically sealing the interior of the medical instrument against ingress of patient body fluids that could otherwise disrupt instrument operation or cause instrument malfunction. While not necessary for accomplishing these functions, it is desirable to attach the filter capacitor 14 to the feedthrough 12 for suppressing or decoupling undesirable EMI signals and noise transmission into the interior of the medical device.

[0022] More particularly, the feedthrough 12 of the feedthrough filter capacitor assembly 10 comprises a ferrule 22 defining an insulator-receiving bore surrounding an insulator 26. Suitable electrically conductive materials for the ferrule 22 include titanium, tantalum, niobium, stainless steel or combinations of alloys thereof, the former being preferred. The ferrule 22 may be of any geometry, non-limiting examples being round, rectangle, and oblong. A surrounding flange 24 (FIG. 3) extends from the ferrule 22 to facilitate attachment of the feedthrough 12 to the casing (not shown) of, for example, one of the previously described implantable medical devices. The method of attachment may be by laser welding or other suitable methods.

[0023] The insulator 26 is of a ceramic material such as of alumina, zirconia, zirconia toughened alumina, aluminum nitride, boron nitride, silicon carbide, glass or combinations thereof. Preferably, the insulating material is alumina, which is highly purified aluminum oxide, and comprises a sidewall 28 extending to a first upper side 30 and a second lower side 32. The insulator 26 is also provided with bores 34 that receive the terminal pins 20 passing therethrough. A layer of metal 36, referred to as metallization, is applied to the insulator sidewall 28 and the sidewall of the terminal pin bores 34 to aid a braze material 38 in hermetically sealing between the ferrule 22 and the insulator 26 and between the terminal pins 20 and the insulator 26, respectively.

[0024] Suitable metallization materials 36 include titanium, titanium nitride, titanium carbide, iridium, iridium oxide, niobium, tantalum, tantalum oxide, ruthenium, ruthenium oxide, zirconium, gold, palladium, molybdenum, silver, platinum, copper, carbon, carbon nitride, and combinations thereof. The metallization layer may be applied by various means including, but not limited to, sputtering, electron-beam deposition, pulsed laser deposition, plating, electroless plating, chemical vapor deposition, vacuum evaporation, thick film application methods, and aerosol spray deposition, and thin cladding.

[0025] Non-limiting examples of braze materials 38 include gold, gold alloys, and silver. Then, if the feedthrough 12 is used where it will contact bodily fluids, the resulting brazes do not need to be covered with a biocompatible coating material. In other embodiments, if the brazes are not biocompatible, for example, if they contain copper, they are coated with a layer/coating of biocompatible/biostable material. Broadly, the biocompatibility requirement is met if contact of the braze/coating with body tissue and blood results in little or no immune response from the body, especially thrombogenicity (clotting) and encapsulation of the electrode with fibrotic tissue. The biostability requirement means that the braze/coating remains physically, electrically, and chemically constant and unchanged over the life of the patient.

[0026] According to one embodiment of the invention, the terminal pins 20 are preferably composed of a first metal comprising a refractory metal. A refractory metal is herein defined as a metal that is resistant to heating and has a melting temperature greater than about 1,800°C. Non-limiting examples of refractory metals include niobium, molybdenum, tantalum, tungsten, rhenium, titanium, vanadium, zirconium, hafnium, osmium, iridium, and alloys thereof. In a more preferred embodiment, the terminal pins 20 comprise niobium and niobium alloys.

[0027] As shown in FIGS. 1-5, 8, 8A, and 9, each terminal pin 20 is received in a throughbore 40 of the terminal block 18. In a preferred embodiment, a proximal end portion 42 of the terminal pin 20 is received in the throughbore 40 of the terminal block 18. Terminal blocks 18 have a terminal block length 44, a terminal block width 46 and a terminal block height 48 (FIG. 4). In a preferred embodiment, the length 44 of the terminal block 18 ranges from about 1mm to about 5mm, the width 46 of the terminal block 18 ranges from about 1mm to about 5mm and the height 48 of the terminal block 18 ranges from about 0.05mm to about 5mm.

[0028] It is preferred that the terminal block 18 is composed of a second metal comprising an electrically conductive metal. Non-limiting examples of conductor block 18 second metals include nickel, titanium, gold, silver, platinum, palladium, stainless steel, MP35N, and alloys thereof. In a more preferred embodiment, terminal blocks 18 are composed of nickel or a nickel alloy.

[0029] Each throughbore 40 of the terminal block 18 is preferably constructed with a diameter ranging from about 0.01mm to about 0.10mm such that the terminal pin 20 can pass therethrough. It is preferred that the terminal pin 20 is positioned such that the bore wall 50 of the terminal block 18 circumferentially surrounds the diameter of the terminal pin 20. It is further preferred that an end portion 54 of the terminal pin 20 resides above the topside surface 52 of the terminal block 18 (FIGS. 3 and 9). In a preferred embodiment, the terminal pin 20 resides from about 0.02mm to about 0.2mm above the top surface 52 of the terminal block 18. Although it is preferred that the end portion 54 of the terminal pin 20 is positioned above the topside surface 52 of the terminal block 18, it is contemplated that the end portion 54 of the terminal pin 20 may be positioned below the top surface 52 of the terminal block 18.

[0030] Furthermore, each terminal block 18 is preferably positioned on the topside 56 of a protective cap 16. In a preferred embodiment, the terminal block 18 resides within a slot 58 formed into the topside surface 56 of the protective cap 16 (FIGS. 1, 4). Each slot 58 is dimensioned such that the width 46 and length 44 of the terminal block 18 fit within the slot 58.

[0031] In addition, the terminal pins 20 are preferably positioned such that they are received through a throughbore 60 of the protective cap 16. More specifically, the proximal portion 42 of the terminal pin 20 is received through the respective throughbores 60 and 40 of the protective cap 16 and the terminal block 18. The protective cap 16 is positioned in a more distal location of the terminal pin 20 than the terminal block 18 (FIG. 3).

[0032] In a preferred embodiment, the protective cap

16 is composed of a biocompatible polymeric material that can withstand temperatures up to about 300°C. It is preferred that the protective cap 16 is composed of a polyoxymethylene copolymer such as CELCON® M450 or HOSTAFORM® C 52021 manufactured by Ticona of Florence, Kentucky. Other non-limiting materials comprising the protective cap 16 include silicone rubber, acrylonitrile butadiene styrene (ABS), polyether ether ketone (PEEK), low and high density polyethylene, polyethylene chloride, polypropylene, acetal, acetylcellulose, acrylic resin, and polytetrafluoroethylene. In an alternate embodiment which is not claimed however, the protective cap 16 may also be composed of a ceramic insulator material.

[0033] In a preferred embodiment, as shown in FIGS. 1, 3, 4, and 9 the protective cap 16 has a height 62 defined by a protective cap sidewall 64 extending from a first protective cap end 66 to a second protective cap end 68, wherein the terminal pin 20 extends through a protective cap throughbore 60 extending from the first protective cap end 66 to the second protective cap end 68. As shown in FIG. 3, the terminal block 18 is positioned in a stacked relationship on the topside surface 56 of the protective cap 16. The respective throughbores 60, 40 of the protective cap 16 and terminal block 18 are aligned such that the proximal region 42 of the terminal pin 20 resides therethrough. It should be noted however, that the protective cap 16 may or may not be incorporated with a feedthrough assembly 10 comprising a capacitor 14.

[0034] In addition, the protective cap 16 is constructed such that a plurality of walls 70 project from the topside surface 56 of the protective cap 16. More preferably, these walls 70 interconnect at a central junction 72 (FIG. 4). These walls 70 have a preferred wall thickness 74 of about 0.5mm to about 5mm, a preferred wall height 76 of about 1mm to about 10mm, and a preferred wall length 78 of about 1mm to about 10mm. The walls 70 electrically insulate the terminal blocks 18 from each other.

[0035] In a specific embodiment of joining niobium to that of nickel, it is preferred that a weld 80 of increased niobium content is formed. Such a weld 80 of increased niobium content is preferred because it reduces mechanical stresses within the niobium-nickel weld 80, thereby increasing the robustness and minimizing weld cracking.

[0036] It is believed that the increased robustness of the weld 80 of the present invention is attributed to the increased niobium content. As can be seen in the nickel - niobium binary phase diagram, illustrated in FIG. 6, an increased niobium content with respect to nickel, reduces the occurrence of inter-metallic phases. As illustrated in the diagram of FIG. 6, there are fewer inter-metallic phases, such as Ni_3Nb_7 and Ni_3Nb, above about 65 weight percent niobium.

[0037] In a preferred embodiment, a full perimeter weld 80 is formed between the first metal of the terminal pin 20 and the second metal of the terminal block 18. More specifically, the weld 80 is formed between the first metal of the terminal pin 20 and terminal block 18, such that weld encompasses the full perimeter 84 of the terminal pin 20. This is shown in FIGS. 1, 2, 4 and 5. It is preferred that the weld 80 is formed about the proximal end region 54 of the terminal pin 20. It is also preferred that the weld 80, as shown in FIGS. 1-5, 8, 8A, and 9, is formed of a shape similar to that of a "button". As illustrated in the cross-sectional view of FIG. 3, this "button" shaped weld 80 is formed above the top surface 52 of the terminal block 18. A "button weld" is herein defined as a weld having the general shape and appearance of that of a button as illustrated in FIGS. 8 and 8A.

[0038] In a preferred embodiment, an alloy is formed comprising a mixture of the first metal of the terminal pin 20 and the second metal of the terminal block 18. In a preferred embodiment, an alloy comprising about 65 weight percent to about 95 weight percent of the first metal is combined with about 35 weight percent to about 5 weight percent of the second metal. In a more preferred embodiment, a weld 80 comprising from about 65 to about 95 weight percent niobium is combined with about 35 to about 5 weight percent nickel.

[0039] As previously mentioned, a niobium content of greater than about 65 weight percent provides for a niobium-nickel alloy with few inter-metallic phases. A weld 100 (FIGS. 7, 7A) comprising inter-metallic phases typically results in an undesirably brittle weld that is prone to cracking. FIGS. 7 and 7A illustrate a cross-sectional view of a prior art weld 100 having cracks 102 therewithin. Weld cracks 102, such as those illustrated and shown in FIGS. 7 and 7A, are typically form during prior art joining processes. It is possible that a crack 102 or multiple cracks 102 could propagate through the weld 100, creating a pathway for the entry of undesirable debris that could disrupt the performance of the feedthrough assembly 10 and/or medical device. In contrast, the weld 80 of the present invention lacks these cracks 102 of the prior art weld 100, as shown in the cross-sectional views of FIGS. 8 and 8A.

[0040] As shown in the illustration and micrograph of FIGS. 7 and 7A, respectively, prior art weld 100 has an appearance of a flat "nail head" which is unlike the preferred "button" shape of the present invention weld 80. It is believed that the curved shape of the preferred "button" weld 80, acts as a stress reducer that contributes to the increased robustness of the present weld 80.

[0041] Furthermore, as shown in the cross-sectional micrograph image of the present weld 80 of FIG. 8A, and the illustration of FIG. 8, there is a distinct boundary layer 106 positioned on either side of the weld 80. This boundary layer 106 delineates the first metal of the terminal pin 20 from the second metal of the terminal block 18. As shown in the illustration and micrograph of FIGS. 8 and 8A, the "button weld" 80 is distinguished from the prior art weld 100 shown in FIGS. 7 and 7A by the presence of the boundary layer 106, a well defined distinct region comprising a mixture of the first metal of the terminal pin 20 and the second metal of the terminal block 18. As shown, the boundary layer 106 has a well defined width

82 extending from the top surface 52 of the terminal block 18 to a position distally from the top surface 52.

[0042] Unlike the weld 80 of the present invention, the prior art weld 100 as shown in the micrograph of FIG. 7A, does not have a distinct boundary layer 106. The prior art weld 100 is characterized by a weld gradient region 104 in which the first metal of the terminal pin 20 appears to gradually diffuse or transition into the second metal of the terminal block 18. This weld gradient region 104 appears of a distinct shade of grey, contrasting between the darker and lighter shades of grey of the terminal pin 20 and terminal block 18, respectively.

[0043] It is believed that the combination of the curved "button" like weld shape and the distinct boundary layers 106 between the first and second metals contributes to the reduced mechanical stress, therefore enabling a crack free weld. In addition, it is believed that the weld gradient region 104 of the prior art weld 100, comprises undesirable inter-metallic phases that contribute to its brittleness.

[0044] The present button weld 80 is manufactured during a welding process by a beam 110 of laser energy focused at a center region 114 of the end 54 of the terminal pin 20, as illustrated in FIG. 9. Focusing the laser energy at substantially the center 114 of the terminal pin 20 provides a concentration of heat there that melts and deforms the first metal of the terminal pin 20. By focusing the heat energy at the center region 114 of the end 54 of the terminal pin 20, the first metal content of the weld 80 is increased. A sufficient amount of heat is generated to effectively form the alloy joining the two dissimilar first and second metals 20, 18 without generating too much heat such that the protective cap 16 and other adjacent materials of the feedthrough assembly 10 are damaged. In addition, focusing the beam of laser energy 110 about the center region 114 of the end 54 of the terminal pin 20, dissipates the energy away from the protective cap 16 thereby minimizing degradation of the adjacent cap 16.

[0045] In a preferred embodiment, a laser welding instrument 108 (FIG. 9) such as a Lasag® model SLS200 is used to join the terminal pin 20 to the terminal block 18. In a preferred embodiment, a laser pulse frequency of between about 10Hz to about 30Hz is used with a pulse width of between about 1.0ms to about 5.0ms to thereby generate a welding energy of from about 1.0J to about 5.0J to weld the dissimilar metals together. These preferred laser welding parameters provide a full perimeter weld 80 that sufficiently joins the two dissimilar metals of the terminal pin 20 and terminal block 18.

[0046] As further shown in FIGS. 2, 4 and 5, the feedthrough assembly 10 includes the filter capacitor 14 that provides for filtering undesirable EMI signals before they can enter the device housing via the terminal pins 20. The filter capacitor 14 comprises a ceramic or ceramic-based dielectric monolith 86 having multiple capacitor-forming conductive electrode plates formed therein. The capacitor dielectric 86 preferably has a circular cross-section matching the cross-section of the ferrule 22 and supports a plurality of spaced-apart layers of first or "active" electrode plates 88 in spaced relationship with a plurality of spaced apart layers of second or "ground" electrode plates 90. The filter capacitor 14 is preferably joined to the feedthrough 12 adjacent to the insulator side 30 by an annular bead 92 of conductive material, such as a solder or braze ring, or a thermal-setting conductive adhesive, and the like. The dielectric 86 includes lead bores 94 provided with an inner surface metallization layer. The terminal pins 20 pass there through and are conductively coupled to the active plates 88 by a conductive braze material 96 contacting between the terminal pins 20 and the bore metallization. In a similar manner, the ground plates 90 are electrically connected through an outer surface metallization 98 and the conductive material 92 to the ferrule 22.

[0047] It is appreciated that various modifications to the invention concepts described herein may be apparent to those of ordinary skill in the art without departing from the scope of the present invention as defined by the appended claims.

Claims

1. A feedthrough assembly (10), which comprises:

a) an insulator (26) of electrically non-conductive material having a height defined by an insulator sidewall (28) extending to spaced apart first (30) and second (32) ends, wherein the insulator (26) has at least one terminal pin bore (34) extending from the first end (30) to the second end (32) thereof;

b) a terminal pin (20) received in the terminal pin bore (34), the terminal pin (20) having a sidewall extending to opposed first (54) and second ends disposed spaced from the respective first (30) and second (32) insulator ends, wherein the terminal pin (20) comprises a first metal, which is a refractory metal;

c) a ferrule (22) of an electrically conductive material and comprising a ferrule opening defined by a surrounding sidewall extending to a ferrule first end and a ferrule second end, wherein the insulator (26) is supported in the ferrule opening;

d) a first braze material (38) hermetically sealing the terminal pin (20) to the insulator (26) and a second braze material (38) hermetically sealing the insulator (26) to the ferrule (22) ;

e) a protective cap (16), being composed of a polymeric material, having a height (62) defined by a protective cap sidewall (64) extending from a protective cap first end (66) to a protective cap second end (68), wherein the terminal pin (20) extends through a protective cap throughbore (60) extending from the protective cap first end

(66) to the protective cap second end (68); and
f) a terminal block (18), comprising a second metal, dissimilar to the first metal, positioned within a slot (58) residing within a topside surface (56) of the protective cap second end (68) such that the terminal pin (20) extends through the protective cap throughbore (60) and a terminal block throughbore (40), wherein a laser weld (80) having a curved shape joins a portion of the first end (54) of the terminal pin (20) to the terminal block (18), the laser weld (80) formed at a top surface (52) of the terminal block (18) and first end (54) of the terminal pin (20), and covers a full perimeter of the terminal pin (20).

2. The feedthrough assembly of claim 1 wherein the second metal is composed of a metal selected from the group consisting of nickel, titanium, gold, silver, platinum, palladium, stainless steel, MP35N, and alloys thereof.

3. The feedthrough assembly of claim 1 or claim 2 wherein the laser weld (80) is characterized as having been formed by a laser (108) at a welding energy from 1.0J to 5.0J, or a welding pulse frequency of between 10Hz to 30Hz, or a welding pulse width of between 1.0ms to 5.0ms.

4. The feedthrough assembly of any of claims 1-3 wherein the laser weld (80) is characterized as having been formed by a laser beam (110) focused about a center region (114) of an end (54) of the terminal pin (20).

5. The feedthrough assembly of any of claims 1-4 wherein the laser weld (80) comprises between 65 to 95 weight percent first metal and between 5 to 35 weight percent second metal.

6. The feedthrough assembly of any of claims 1-5 wherein the laser weld (80) is **characterized by** a boundary layer (106) that delineates the first and second metals.

7. The feedthrough assembly of any of claims 1-6 wherein the protective cap (16) is composed of a biocompatible polymeric material.

8. A method for providing a feedthrough assembly (10), comprising the steps of:

a) providing a feedthrough comprising:

i) an insulator (26) of electrically non-conductive material having a height defined by an insulator sidewall (28) extending to spaced apart first (30) and second (32) ends, wherein the insulator (26) has at least one terminal pin bore (34) extending from the first end (30) to the second end (32) thereof;
ii) a terminal pin (20) received in the terminal pin bore (34), the terminal pin (20) having a sidewall extending to opposed first (54) and second ends disposed spaced from the respective first (30) and second (32) insulator ends, wherein the terminal pin (20) comprises a first metal, which is a refractory metal;
iii) a ferrule (22) of an electrically conductive material and comprising a ferrule opening defined by a surrounding sidewall extending to a ferrule first end and a ferrule second end, wherein the insulator (26) is supported in the ferrule opening;
iv) a first braze material (38) hermetically sealing the terminal pin (20) to the insulator (26) and a second braze material (38) hermetically sealing the insulator (26) to the ferrule (22);
v) a protective cap (16), being composed of a polymeric material, having a height (62) defined by a protective cap sidewall (64) extending from a protective cap first end (66) to a protective cap second end (68), wherein the terminal pin (20) extends through a protective cap throughbore (60) extending from the protective cap first end (66) to the protective cap second end (68); and
vi) a terminal block (18), comprising a second metal, dissimilar to the first metal, positioned within a slot (58) residing within a topside surface (56) of the second end (68) of the protective cap (16) such that the terminal pin (20) extends through the protective cap throughbore (60) and a terminal block throughbore (40), wherein the terminal pin (20) is joined to the terminal block (18); and

b) joining the proximal end portion (54) of the terminal pin (20) to the terminal block (18) with a laser weld (80), having a curved shape, the laser weld (80) formed at a top surface (52) of the terminal block (18) and the first end (54) of the terminal pin (20), and covers a full perimeter of the terminal pin (20).

9. The method of claim 8 including applying a laser weld energy of 1.0J to 5.0J, or a welding pulse frequency of between 10Hz to 30Hz, or a welding pulse width of between 1.0ms to 5.0ms to the terminal pin (20).

10. The method of claim 8 or claim 9 including focusing a laser beam (110) about a center region (114) of an end (54) of the terminal pin (20).

11. The method of any of claims 8-10 including providing the laser weld (80) comprising between 65 to 95 weight percent first metal and between 5 to 35 weight percent second metal.

12. The method of any of claims 8-11 including providing the protective cap (16) composed of a biocompatible polymeric material.

13. The method of any of claims 8-12 including selecting the second metal from the group consisting of nickel, titanium, gold, silver, platinum, palladium, stainless steel, MP35N, and alloys thereof.

Patentansprüche

1. Durchführungsanordnung (10), die Folgendes umfasst:

a) einen Isolator (26) aus elektrisch nichtleitendem Material, mit einer Höhe, die durch eine Isolatorseitenwand (28) definiert wird, die sich zu voneinander beabstandeten ersten (30) und zweiten (32) Enden erstreckt, wobei der Isolator (26) mindestens eine Anschlussstiftbohrung (34) aufweist, die sich von dem ersten Ende (30) zu dem zweiten Ende (32) davon erstreckt;
b) einen Anschlussstift (20), der in der Anschlussstiftbohrung (34) empfangen wird, wobei der Anschlussstift (20) eine Seitenwand aufweist, die sich zu gegenüberliegenden erste (54) und zweiten Enden erstreckt, die beabstandet von den jeweiligen ersten (30) und zweiten (32) Isolatorenden angeordnet sind, wobei der Anschlussstift (20) ein ersten Metall umfasst, das ein hitzebeständiges Metall ist;
c) eine Hülse (22) aus einem elektrisch leitfähigen Material, die eine Hülsenöffnung umfasst, die durch eine umlaufende Seitenwand definiert wird, die sich zu einem ersten Hülsenende und einem zweiten Hülsenende erstreckt, wobei der Isolator (26) in der Hülsenöffnung gestützt wird;
d) ein erstes Lötmaterial (38), das den Anschlussstift (20) an dem Isolator (26) hermetisch abdichtet und ein zweites Lötmaterial (38), das den Isolator (26) an der Hülse (22) hermetisch abdichtet;
e) eine Schutzkappe (16), die aus einem Polymermaterial besteht und eine Höhe (62) aufweist, die von einer Schutzkappenseitenwand (64) definiert wird, die sich von einem ersten Ende (66) der Schutzkappe zu einem zweiten Ende (68) der Schutzkappe erstreckt, wobei sich der Anschlussstift (20) durch eine Durchgangsbohrung (60) der Schutzkappe erstreckt, die sich von dem ersten Ende (66) der Schutzkappe zu dem zweiten Ende (68) der Schutzkappe erstreckt; und
f) einen Anschlussblock (18), der ein zweites Metall umfasst, das dem ersten Metall unähnlich ist und der in einem Schlitz (58) angeordnet ist, der sich in einer Oberseitenfläche (56) des zweiten Endes (68) der Schutzkappe befindet, so dass sich der Anschlussstift (20) durch die Durchgangsbohrung (60) der Schutzkappe und eine Durchgangsbohrung (40) des Anschlussblocks erstreckt, wobei eine Laserschweißnaht (80) mit einer gekrümmten Form einen Abschnitt des ersten Endes (54) des Anschlussstiftes (20) mit dem Anschlussblock (18) verbindet, wobei die Laserschweißnaht (80) an einer Oberseite (52) des Anschlussblocks (18) und am ersten Ende (54) des Anschlussstift (20) gebildet ist und einen gesamten Umfang des Anschlussstiftes (20) abdeckt.

2. Durchführungsanordnung nach Anspruch 1, wobei das zweite Metall aus einem Metall besteht, das aus der Gruppe ausgewählt wird, die aus Folgendem besteht: Nickel, Titan, Gold, Silber, Platin, Palladium, Edelstahl, MP35N und Legierungen davon.

3. Durchführungsanordnung nach Anspruch 1 oder Anspruch 2, wobei die Laserschweißnaht (80) **dadurch gekennzeichnet ist, dass** sie von einem Laser (108) mit einer Schweißenergie von 1,0 J bis 5,0 J oder einer Schweißpulsfrequenz von 10 Hz bis 30 Hz oder einer Schweißimpulsbreite von 1,0 ms bis 5,0 ms gebildet wurde.

4. Durchführungsanordnung nach einem der Ansprüche 1 bis 3, wobei die Laserschweißnaht (80) **dadurch gekennzeichnet ist, dass** sie von einem Laserstrahl (110) gebildet wurde, der auf einen Mittelbereich (114) eines Endes (54) des Anschlussstiftes (20) fokussiert ist.

5. Durchführungsanordnung nach einem der Ansprüche 1 bis 4, wobei die Laserschweißnaht (80) 65 bis 95 Gewichtsprozent des ersten Metalls und 5 bis 35 Gewichtsprozent des zweiten Metalls umfasst.

6. Durchführungsanordnung nach einem der Ansprüche 1 bis 5, wobei die Laserschweißnaht (80) durch eine Grenzschicht (106) gekennzeichnet ist, die das erste und zweite Metall abgrenzt.

7. Durchführungsanordnung nach einem der Ansprüche 1 bis 6, wobei die Schutzkappe (16) aus einem biokompatiblen polymeren Material besteht.

8. Verfahren zum Bereitstellen einer Durchführungsanordnung (10), das folgende Schritte umfasst:

a) Bereitstellen einer Durchführung, die Folgendes umfasst:

i) einen Isolator (26) aus elektrisch nichtleitendem Material, mit einer Höhe, die durch eine Isolatorseitenwand (28) definiert wird, die sich zu voneinander beabstandeten ersten (30) und zweiten (32) Enden erstreckt, wobei der Isolator (26) mindestens eine Anschlussstiftbohrung (34) aufweist, die sich von dem ersten Ende (30) zu dem zweiten Ende (32) davon erstreckt;
ii) einen Anschlussstift (20), der in der Anschlussstiftbohrung (34) empfangen wird, wobei der Anschlussstift (20) eine Seitenwand aufweist, die sich zu gegenüberliegenden erste (54) und zweiten Enden erstreckt, die beabstandet von den jeweiligen ersten (30) und zweiten (32) Isolatorenden angeordnet sind, wobei der Anschlussstift (20) ein ersten Metall umfasst, das ein hitzebeständiges Metall ist;
iii) eine Hülse (22) aus einem elektrisch leitfähigen Material, die eine Hülsenöffnung umfasst, die durch eine umlaufende Seitenwand definiert wird, die sich zu einem ersten Hülsenende und einem zweiten Hülsenende erstreckt, wobei der Isolator (26) in der Hülsenöffnung gestützt wird;
iv) ein erstes Lötmaterial (38), das den Anschlussstift (20) an dem Isolator (26) hermetisch abdichtet und ein zweites Lötmaterial (38),
das den Isolator (26) an der Hülse (22) hermetisch abdichtet;
v) eine Schutzkappe (16), die aus einem Polymermaterial besteht und eine Höhe (62) aufweist, die von einer Schutzkappenseitenwand (64) definiert wird, die sich von einem ersten Ende (66) der Schutzkappe zu einem zweiten Ende (68) der Schutzkappe erstreckt, wobei sich der Anschlussstift (20) durch eine Durchgangsbohrung (60) der Schutzkappe erstreckt, die sich von dem ersten Ende (66) der Schutzkappe zu dem zweiten Ende (68) der Schutzkappe erstreckt; und
vi) einen Anschlussblock (18), der ein zweites Metall umfasst, das dem ersten Metall unähnlich ist und der in einem Schlitz (58) angeordnet ist, der sich in einer Oberseitenfläche (56) des zweiten Endes (68) der Schutzkappe befindet, so dass sich der Anschlussstift (20) durch die Durchgangsbohrung (60) der Schutzkappe und eine Durchgangsbohrung (40) des Anschlussblocks erstreckt, wobei der Anschlussstift (20) mit dem Anschlussblock (18) verbunden ist; und

b) Verbinden des proximalen Endabschnitts (54) des Anschlussstifts (20) mit dem Anschlussblock (18) mit Hilfe einer Laserschweißnaht (80), die eine gekrümmte Form aufweist, wobei die Laserschweißnaht (80) an einer Oberseite (52) des Anschlussblocks (18) und am ersten Ende (54) des Anschlussstift (20) gebildet ist und einen gesamten Umfang des Anschlussstiftes (20) abdeckt.

9. Verfahren nach Anspruch 8, das das Anlegen einer Laserschweißenergie von 1.0 J bis 5,0 J oder einer Schweißpulsfrequenz von 10 Hz bis 30 Hz oder einer Schweißimpulsbreite von 1,0 ms bis 5,0 ms an den Anschlussstift (20) umfasst.

10. Verfahren nach Anspruch 8 oder Anspruch 9, das das Fokussieren eines Laserstrahls (110) auf einen Mittelbereich (114) eines Endes (54) des Anschlussstiftes (20) umfasst.

11. Verfahren nach einem der Ansprüche 8 bis 10, das das Bereitstellen der Laserschweißnaht (80) umfasst, die 65 bis 95 Gewichtsprozent des ersten Metalls und 5 bis 35 Gewichtsprozent des zweiten Metalls umfasst.

12. Verfahren nach einem der Ansprüche 8 bis 11, dass das Bereitstellen der Schutzkappe (16) umfasst, die aus einem biokompatiblen polymeren Material besteht.

13. Verfahren nach einem der Ansprüche 8 bis 12, das das Auswählen des zweiten Metalls aus der Gruppe umfasst, die aus Nickel, Titan, Gold, Silber, Platin, Palladium, Edelstahl, MP35N und Legierungen davon besteht.

Revendications

1. Ensemble de traversée (10), qui comporte :

a) un isolateur (26) réalisé en un matériau électriquement non conducteur ayant une hauteur définie par une paroi latérale (28) de l’isolateur s’étendant jusque des première (30) et deuxième (32) extrémités espacées l’une par rapport à l’autre, dans lequel l’isolateur (26) a au moins un alésage (34) de broche de borne s’étendant depuis la première extrémité (30) jusqu’à la deuxième extrémité (32) de celui-ci ;
b) une broche de borne (20) reçue dans l’alésage (34) de broche de borne, la broche de borne (20) ayant une paroi latérale s’étendant jusqu’à des première (54) et deuxième extrémités opposées disposées de manière espacée par rapport aux première (30) et deuxième (32) extré-

mités respectives de l'isolateur, dans lequel la broche de borne (20) comporte un premier métal, qui est un métal réfractaire ;

c) une bague (22) réalisée en un matériau électriquement conducteur et comportant une ouverture de bague définie par une paroi latérale circonvoisine s'étendant jusqu'à une première extrémité de bague et une deuxième extrémité de bague, dans lequel l'isolateur (26) est supporté dans l'ouverture de la bague ;

d) un premier matériau de brasure (38) servant à sceller de manière hermétique la broche de borne (20) au niveau de l'isolateur (26) et un deuxième matériau de brasure (38) servant à sceller de manière hermétique l'isolateur (26) au niveau de la bague (22) ;

e) un capuchon de protection (16), étant composé d'un matériau polymère, ayant une hauteur (62) définie par une paroi latérale (64) du capuchon de protection s'étendant depuis une première extrémité (66) du capuchon de protection jusqu'à une deuxième extrémité (68) du capuchon de protection, dans lequel la broche de borne (20) s'étend au travers d'un alésage traversant (60) du capuchon de protection s'étendant depuis la première extrémité (66) du capuchon de protection jusqu'à la deuxième extrémité (68) du capuchon de protection ; et

f) une plaque à bornes (18), comportant un deuxième métal, différent du premier métal, positionnée à l'intérieur d'une fente (58) résidant à l'intérieur d'une surface côté supérieur (56) de la deuxième extrémité (68) du capuchon de protection de telle sorte que la broche de borne (20) s'étend au travers de l'alésage traversant (60) du capuchon de protection et d'un alésage traversant (40) de la plaque à bornes, dans lequel une soudure au laser (80) ayant une forme courbe joint une partie de la première extrémité (54) de la broche de borne (20) sur la plaque à bornes (18), la soudure au laser (80) étant formée au niveau d'une surface supérieure (52) de la plaque à bornes (18) et d'une première extrémité (54) de la broche de borne (20), et recouvre tout un périmètre de la broche de borne (20).

2. Ensemble de traversée selon la revendication 1, dans lequel le deuxième métal est composé d'un métal sélectionné dans le groupe constitué par du nickel, du titane, de l'or, de l'argent, du platine, du palladium, de l'acier inoxydable, de l'alliage MP35N, et des alliages de ceux-ci.

3. Ensemble de traversée selon la revendication 1 ou la revendication 2, dans lequel la soudure au laser (80) est caractérisée comme ayant été formée par un laser (108) à une énergie de soudage comprise entre 1,0 J et 5,0 J, ou une fréquence d'impulsion de soudage comprise entre 10 Hz et 30 Hz, ou une durée d'impulsion de soudage comprise entre 1,0 ms et 5,0 ms.

4. Ensemble de traversée selon l'une quelconque des revendications 1 à 3, dans lequel la soudure au laser (80) est caractérisée comme ayant été formée par un faisceau laser (110) focalisé autour d'une région centrale (114) d'une extrémité (54) de la broche de borne (20).

5. Ensemble de traversée selon l'une quelconque des revendications 1 à 4, dans lequel la soudure au laser (80) comporte entre 65 et 95 pour cent en poids du premier métal et entre 5 et 35 pour cent en poids du deuxième métal.

6. Ensemble de traversée selon l'une quelconque des revendications 1 à 5, dans lequel la soudure au laser (80) est **caractérisée par** une couche limite (106) qui délimite les premier et deuxième métaux.

7. Ensemble de traversée selon l'une quelconque des revendications 1 à 6, dans lequel le capuchon de protection (16) est composé d'un matériau polymère biocompatible.

8. Procédé permettant la mise en oeuvre d'un ensemble de traversée (10), comportant les étapes consistant à :

a) mettre en oeuvre une traversée comportant :

i) un isolateur (26) réalisé en un matériau électriquement non conducteur ayant une hauteur définie par une paroi latérale (28) de l'isolateur s'étendant jusque des première (30) et deuxième (32) extrémités espacées l'une par rapport à l'autre, dans lequel l'isolateur (26) a au moins un alésage (34) de broche de borne s'étendant depuis la première extrémité (30) jusqu'à la deuxième extrémité (32) de celui-ci ;

ii) une broche de borne (20) reçue dans l'alésage (34) de broche de borne, la broche de borne (20) ayant une paroi latérale s'étendant jusqu'à des première (54) et deuxième extrémités opposées disposées de manière espacée par rapport aux première (30) et deuxième (32) extrémités respectives de l'isolateur, dans lequel la broche de borne (20) comporte un premier métal, qui est un métal réfractaire ;

iii) une bague (22) réalisée en un matériau électriquement conducteur et comportant une ouverture de bague définie par une paroi latérale circonvoisine s'étendant jusqu'à une première extrémité de bague et une deuxième extrémité de bague, dans lequel l'isolateur (26) est supporté dans l'ouverture de la bague ;

iv) un premier matériau de brasure (38) servant à sceller de manière hermétique la broche de borne (20) au niveau de l'isolateur (26) et un deuxième matériau de brasure (38) servant à sceller de manière hermétique l'isolateur (26) au niveau de la bague (22) ;

v) un capuchon de protection (16), étant composé d'un matériau polymère, ayant une hauteur (62) définie par une paroi latérale (64) du capuchon de protection s'étendant depuis une première extrémité (66) du capuchon de protection jusqu'à une deuxième extrémité (68) du capuchon de protection, dans lequel la broche de borne (20) s'étend au travers d'un alésage traversant (60) du capuchon de protection s'étendant depuis la première extrémité (66) du capuchon de protection jusqu'à la deuxième extrémité (68) du capuchon de protection ; et

vi) une plaque à bornes (18), comportant un deuxième métal, différent du premier métal, positionnée à l'intérieur d'une fente (58) résidant à l'intérieur d'une surface côté supérieur (56) de la deuxième extrémité (68) du capuchon de protection (16) de telle sorte que la broche de borne (20) s'étend au travers de l'alésage traversant (60) du capuchon de protection et d'un alésage traversant (40) de la plaque à bornes, dans lequel la broche de borne (20) est jointe sur la plaque à bornes (18) ; et

b) joindre la partie d'extrémité proximale (54) de la broche de borne (20) sur la plaque à bornes (18) au moyen d'une soudure au laser (80), ayant une forme courbe, la soudure au laser (80) étant formée au niveau d'une surface supérieure (52) de la plaque à bornes (18) et de la première extrémité (54) de la broche de borne (20), et recouvrir tout un périmètre de la broche de borne (20).

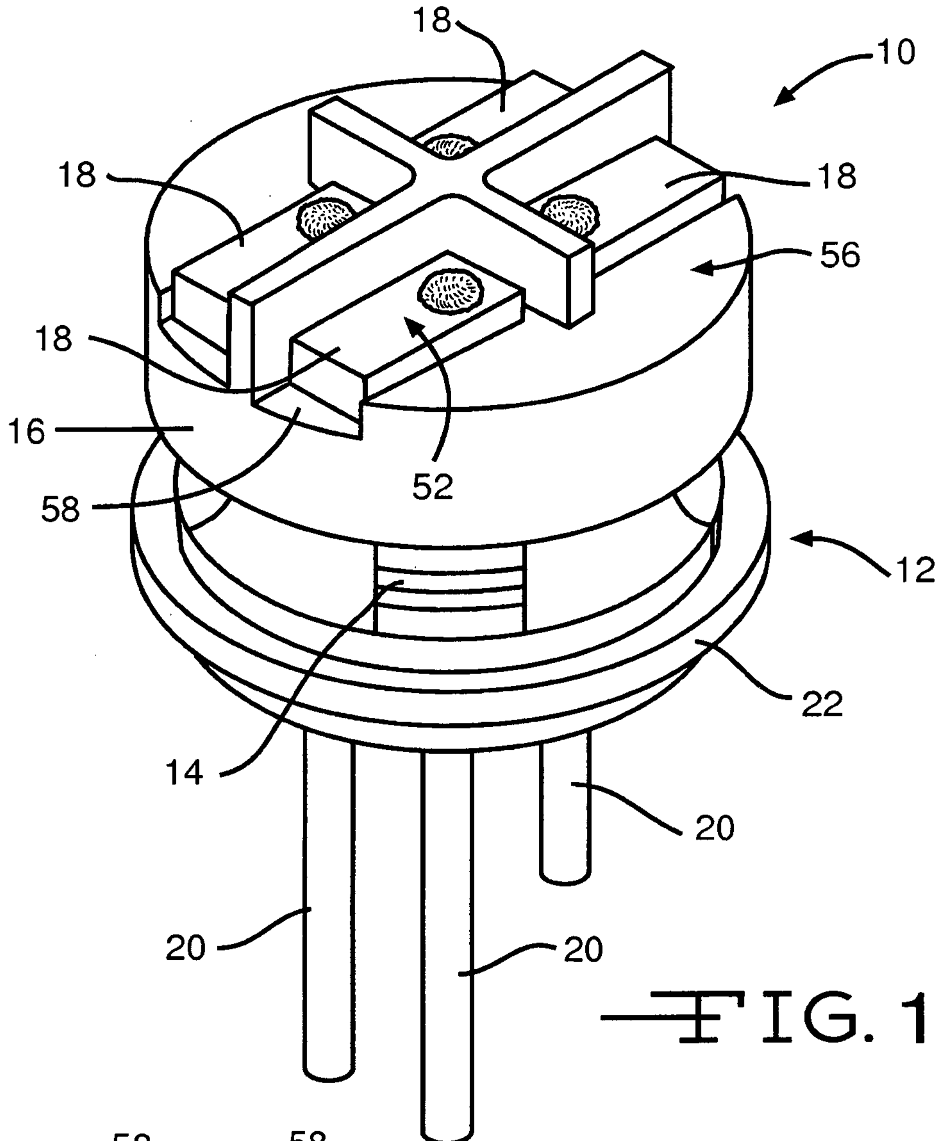
9. Procédé selon la revendication 8, comprenant l'étape consistant à appliquer une énergie de soudage au laser comprise entre 1,0 J et 5,0 J, ou une fréquence d'impulsion de soudage comprise entre 10 Hz et 30 Hz, ou une durée d'impulsion de soudage comprise entre 1,0 ms et 5,0 ms sur la broche de borne (20).

10. Procédé selon la revendication 8 ou la revendication 9, comprenant l'étape consistant à focaliser un faisceau laser (110) autour d'une région centrale (114) d'une extrémité (54) de la broche de borne (20).

11. Procédé selon l'une quelconque des revendications 8 à 10, comprenant l'étape consistant à mettre en oeuvre la soudure au laser (80) comportant entre 65 et 95 pour cent en poids du premier métal et entre 5 et 35 pour cent en poids du deuxième métal.

12. Procédé selon l'une quelconque des revendications 8 à 11, comprenant l'étape consistant à mettre en oeuvre le capuchon de protection (16) composé d'un matériau polymère biocompatible.

13. Procédé selon l'une quelconque des revendications 8 à 12, comprenant l'étape consistant à sélectionner le deuxième métal dans le groupe constitué par du nickel, du titane, de l'or, de l'argent, du platine, du palladium, de l'acier inoxydable, de l'alliage MP35N, et des alliages de ceux-ci.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16
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20

FIG. 1

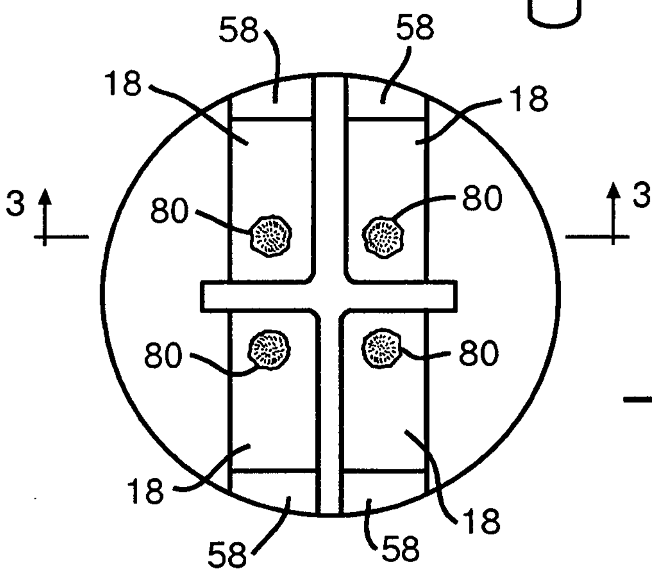
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FIG. 2

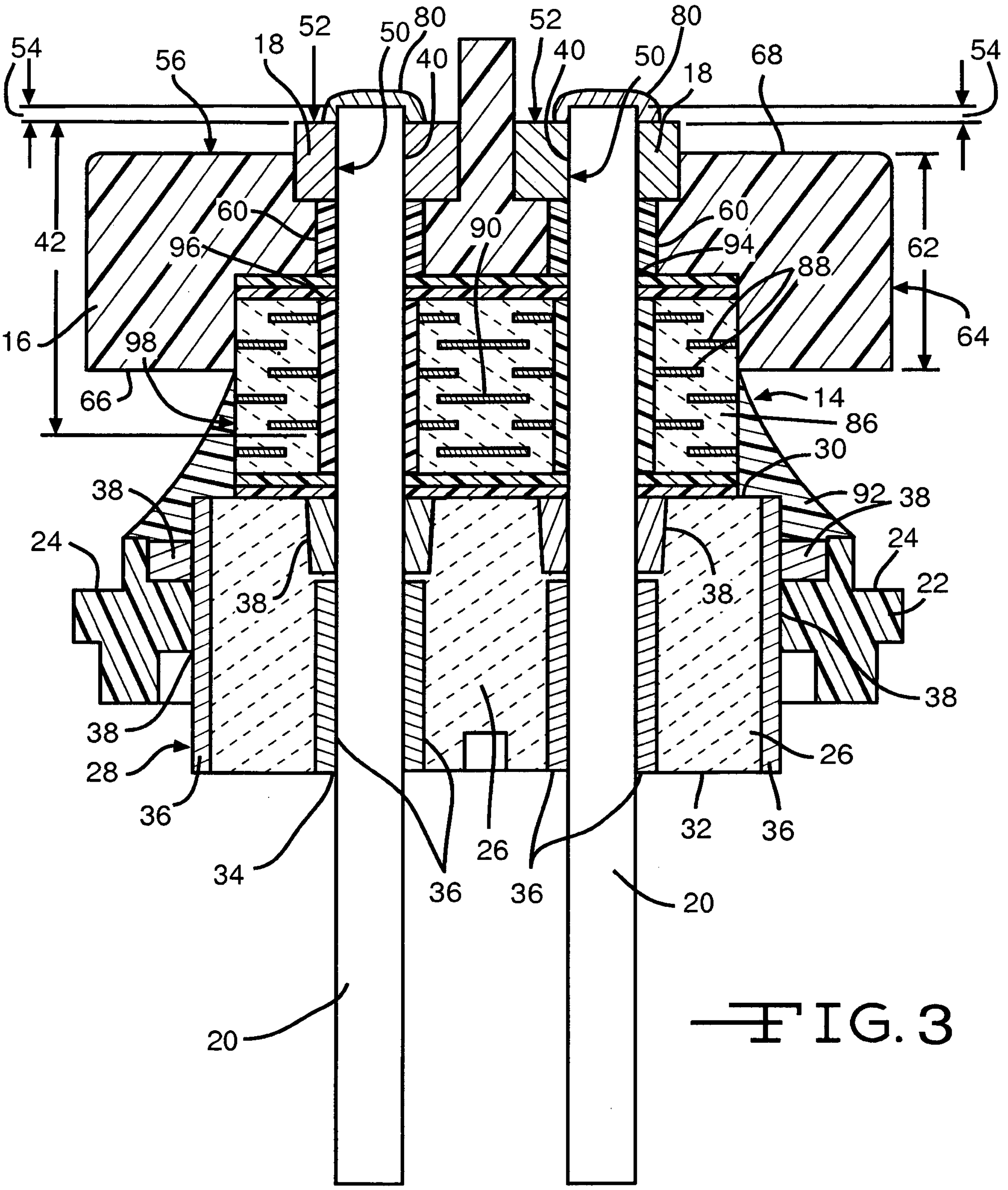
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FIG. 3

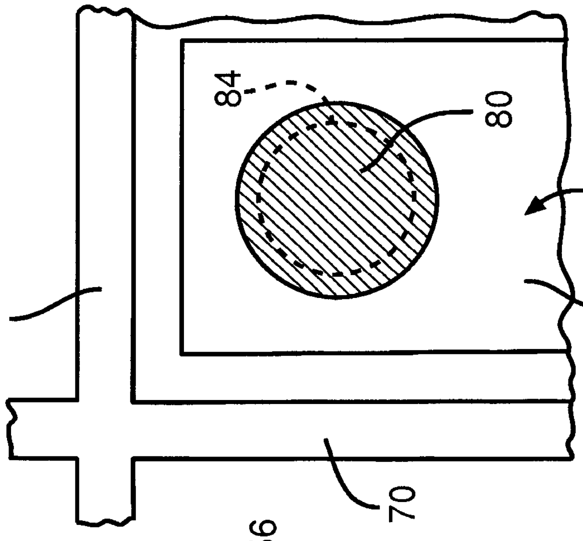
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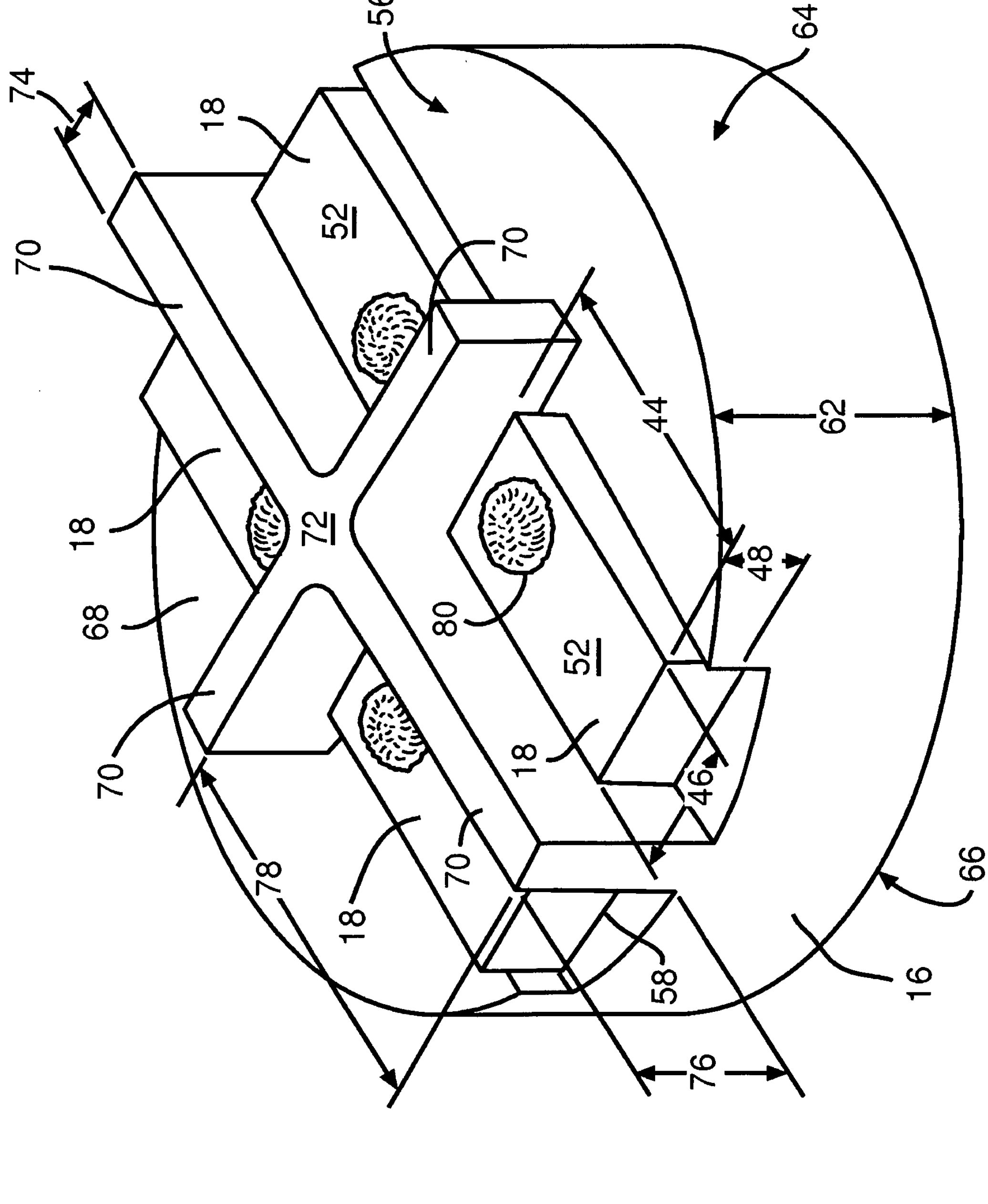
FIG. 5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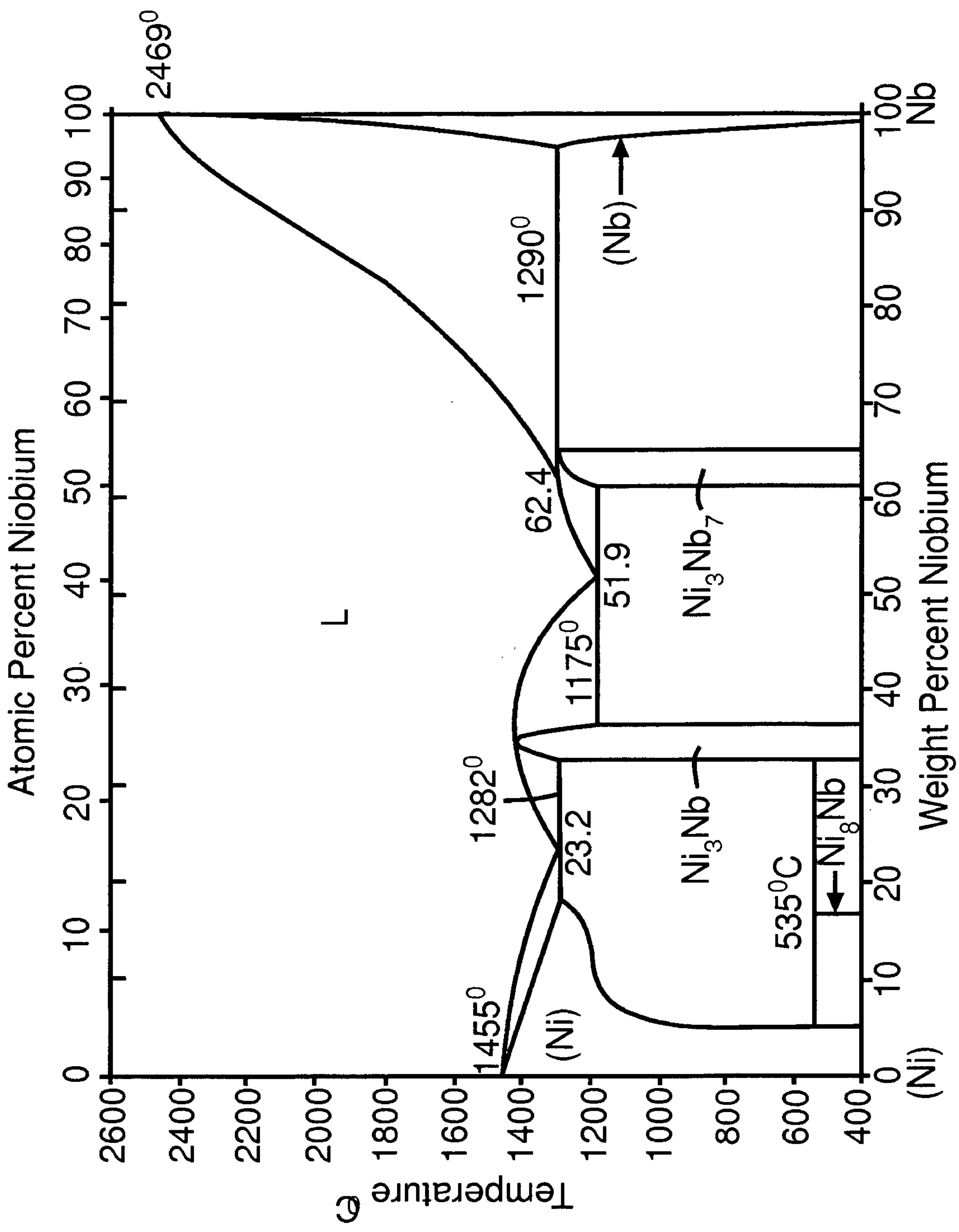
18
58
76
66
16

FIG. 4



Atomic Percent Niobium
Weight Percent Niobium
Temperature C
L
(Ni)
(Nb)
Nb
2469⁰
1455⁰
1282⁰
1290⁰
1175⁰
535⁰C
62.4
51.9
23.2
Ni_3Nb
Ni_3Nb_7
Ni_8Nb

FIG. 6

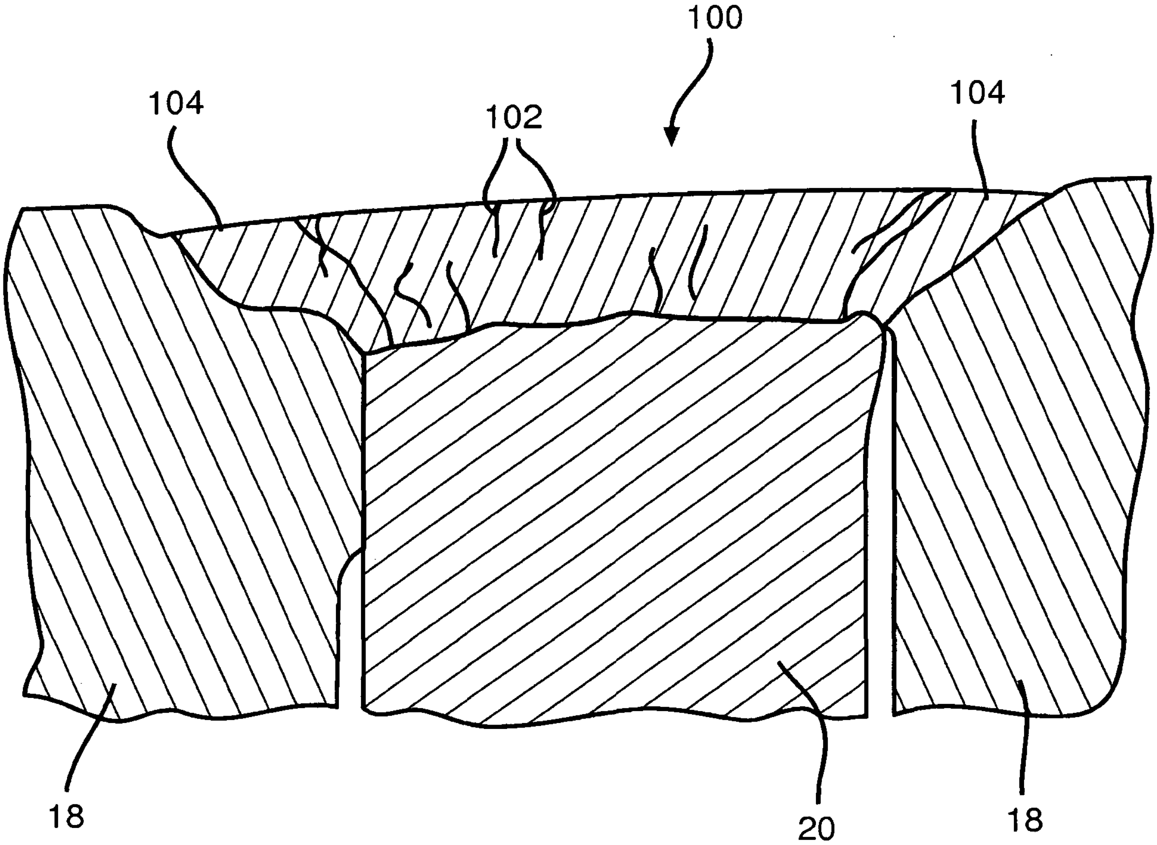


FIG. 7
Prior Art

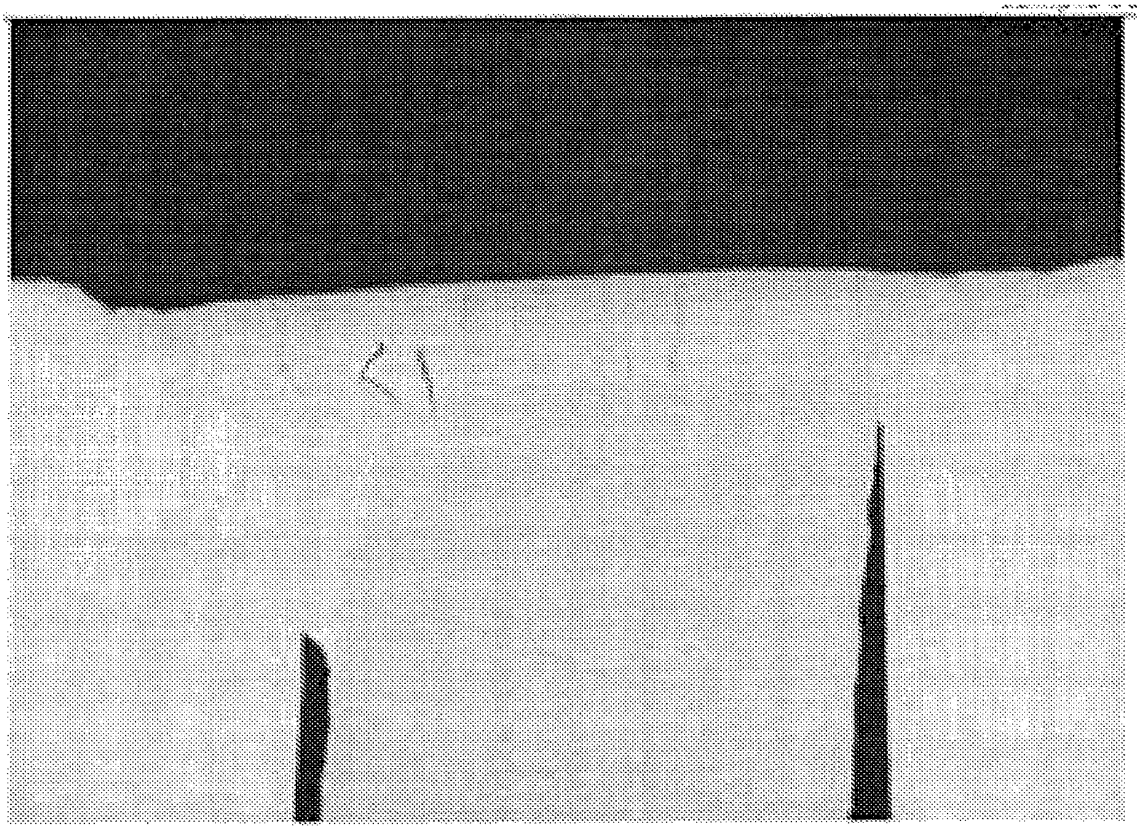


FIG. 7A
Prior Art

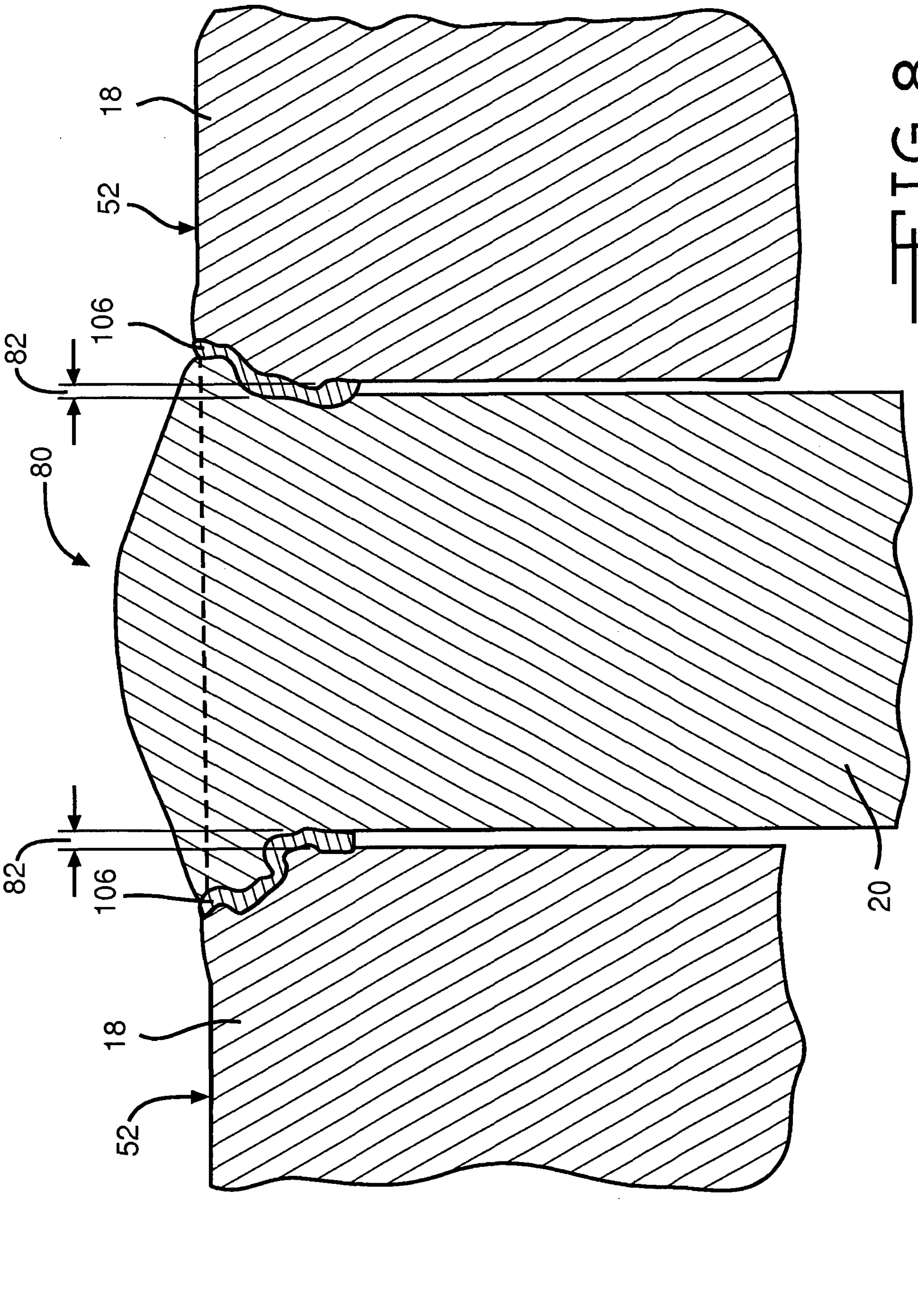


FIG. 8

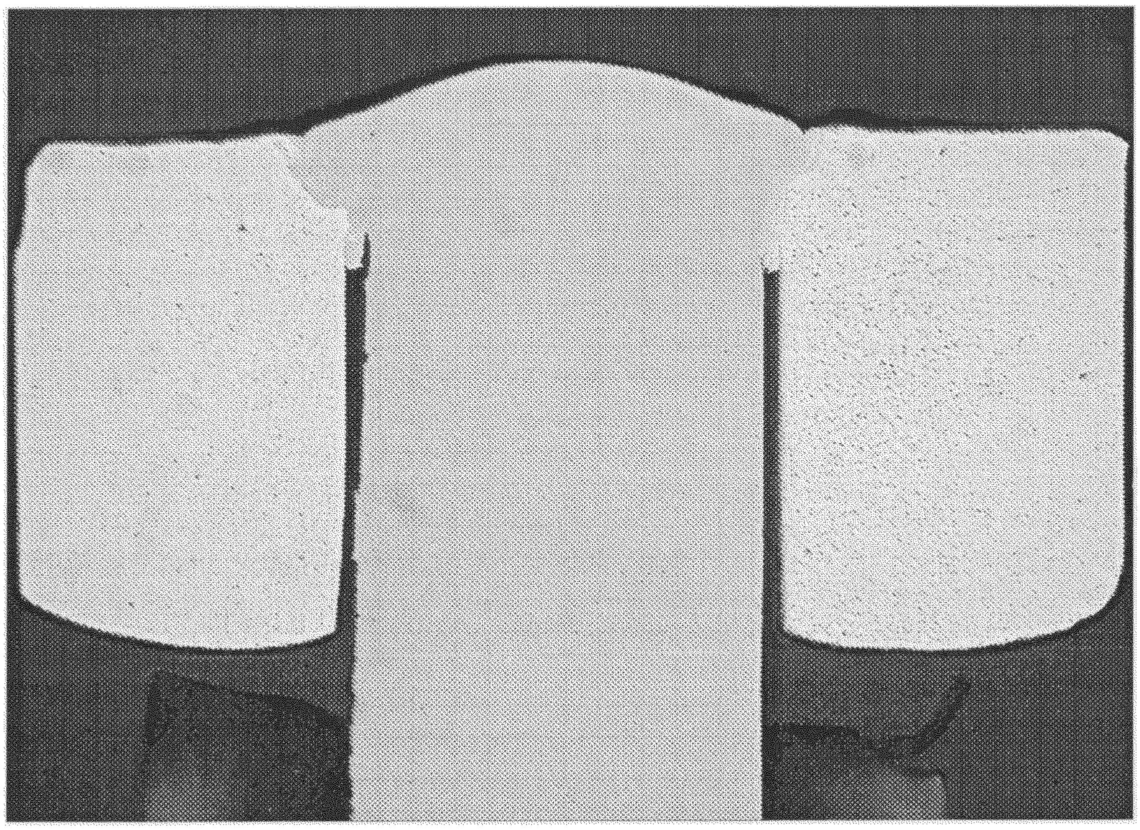


FIG. 8A

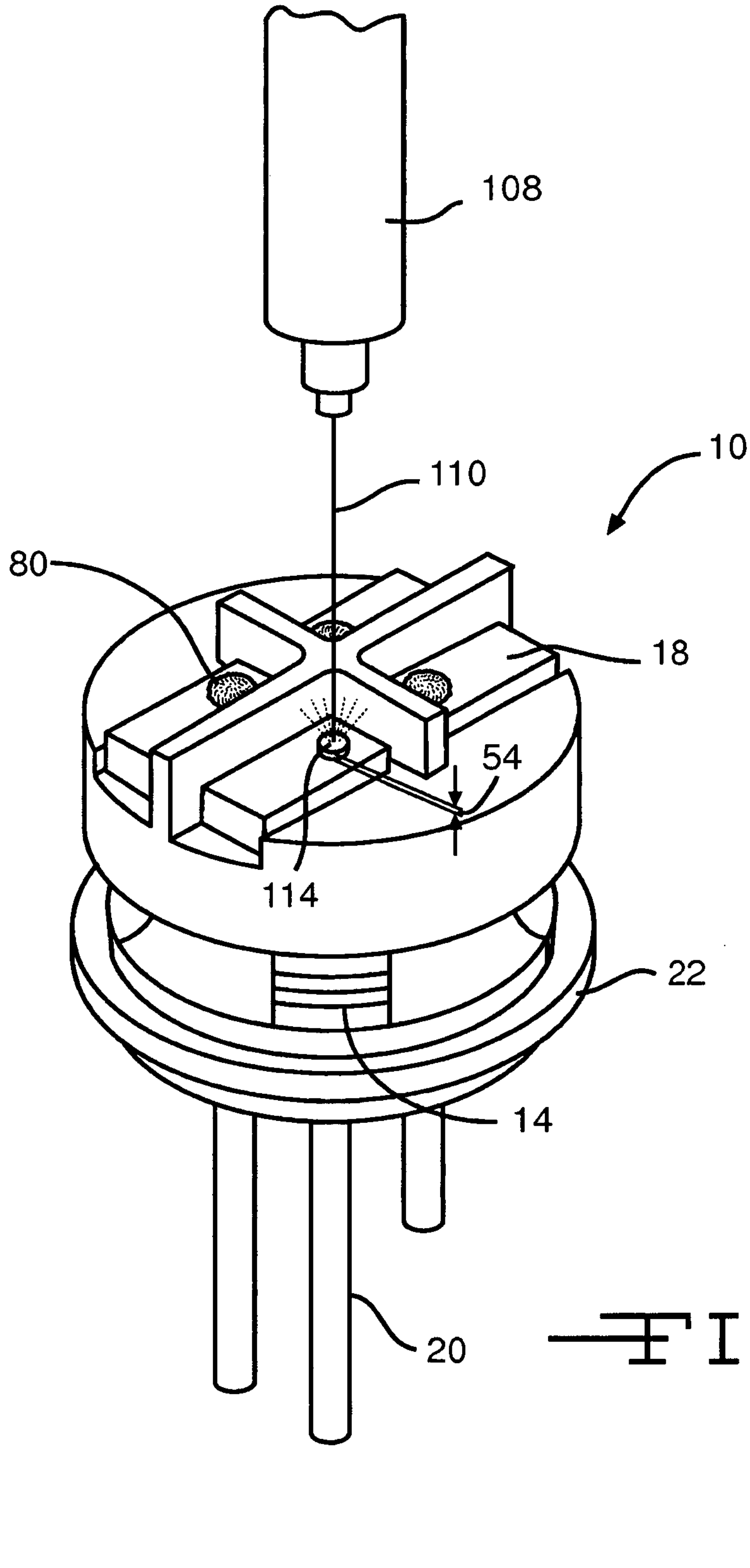


FIG. 9

REFERENCES CITED IN THE DESCRIPTION

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