**Title:** ELECTRICAL CONNECTOR FOR CARDIAC DEVICES

**Abstract:** A temporary cardiac pacing wire (10), or a similar device, includes an electrically conductive lead (18) which is folded over on itself to form a plug assembly (566) for connection to a pacing or monitoring apparatus (30). In the case of a bipolar temporary cardiac pacing wire (10), flexible wires (18, 20) are employed, one of which (18) has two elongated conductive sections (26, 28) near its proximal end, which form the plug assembly (566). The plug assembly (566) can be provided with a resilient insulating sheath (564) covering and insulating its entire length. The insulating sheath (564) automatically retracts in accordion-like fashion as the plug assembly (566) is connected to the pacing or monitoring apparatus (30, 530) and also automatically or manually extends as the plug assembly (566) is withdrawn from the pacing or monitoring apparatus (30, 530). The insulating sheath (564) can be provided with a coil spring (684) to encourage automatic extension of the sheath (564) and with an end flap (686) to further insulate the tip of an otherwise uninsulated plug assembly (566).
ELECTRICAL CONNECTOR FOR CARDIAC DEVICES

Technical Field of the Invention

The present invention relates to electrical connectors for cardiac devices. More particularly, the present invention relates to temporary cardiac pacing wires that are adapted for use with apparatus that generate electrical signals suitable for stimulating, pacing, sensing, monitoring or defibrillating the heart.

Background Art

Devices to stimulate or regulate cardiac function have been known and used for decades. They involve a power source (pacemaker) and one or more surgical electrodes to attach the source to the heart. They are generally of two types.

Implantable pacers are intended for long-term use and, as the name suggests, are entirely implanted in the body. The other type is intended for temporary use. The temporary pacemaker is located outside the body and is connected to the heart by a surgical electrode called a "temporary pacing wire." Although surgical electrodes are used for preparing electrocardiograms and other applications, for the sake of brevity, the description that follows is focused on temporary pacing wires.
In general, such wires are constructed of a number of fine, stainless steel wires braided or twisted together to form a single, flexible, multi-strand electrode wire. The major portion of the wire is electrically insulated with a polyethylene, polytetrafluoroethylene, silicon, nylon, or another non-conducting coating, with a short length of wire at either end left uninsulated. To the distal uninsulated end of the electrode wire there is attached, by swaging or other means, a fine curved needle for piercing the heart tissue to place the uninsulated end of the electrode in the myocardium. At the proximal end of the electrode wire, a straight (e.g., Keith-type) cutting needle is attached for piercing the thoracic wall to lead the electrode to an outer point for connection with the pacemaker. Once that has been accomplished, the needle, or its sharp-pointed end, is clipped or broken off and the proximal end of the electrode is readied for attachment to the pacemaker as required to stimulate or regulate the beating of the heart. A single setup involves two electrodes, i.e., two temporary pacing wires. During the time that the temporary pacing wire is performing its function, the uninsulated end of the electrode must remain anchored in the myocardium. The anchorage must be secure, lest the continually beating heart cause the wire to be expelled from the myocardium. When the need for the pacing wire has passed, it is necessary to remove from the body the wire that runs from the external pacemaker to the myocardium.

The process of preparing the proximal ends of the pacing wires
(electrodes) to the pacemaker requires numerous steps and is time consuming. Not only do the proximal ends of the pacing wires require removal from the Keith-like needles, but separate steps are required to make them suitably adapted for attachment to electrodes (terminals) within the pacemaker.

In addition, when the uninsulated proximal ends of the pacing wires are not inserted into sockets in the pacemaker for contact with the electrodes therein, they are exposed to the surrounding environment. This means that the uninsulated proximal ends of the wires are susceptible to accidental electrical contact with conducting surfaces, which would result in unintentional and possibly dangerous stimulation of the patient's heart.

Description of the Related Art

U.S. Patent No. 4,693,258, issued on September 15, 1987 to Osypka et al., discloses an electrode connector assembly that can be used to electrically connect the proximal end of a pacing wire (with insulation removed) to the socket of a pacing or monitoring instrument. This approach is useful but requires many small parts to be assembled. This may prove to be difficult and time consuming to work with in the operating room environment. Also, multistrand wires have a tendency to fray which adds to difficulties. Additionally, small parts are prone to be easily lost.
U.S. Patent No. 4,633,880, issued on January 6, 1987 to Osypka et al., discloses an implantable bipolar electrode assembly where the two distal ends of the wire are received in an electrically conductive sleeve (pole). One wire is in electrical contact with the sleeve and the second wire passes through the sleeve. The distal end of the second wire is stripped of insulation to provide electrical contact with heart tissue. The stripped section is configured to introduce mechanical resistance to its removal from heart tissue. Although this electrode assembly is effective in delivering a bipolar signal to the heart, it is not intended for use as a direct electrical connection with a pacemaker.

U.S. Patent No. 5,792,217, issued on August 11, 1998 to Camps et al., discloses an arrangement in which the proximal ends of two pacing wires can be simultaneously broken away from a Keith-type needle. Affixed to the proximal end of each wire is an electrical connector that is suitably dimensioned to connect to a pacing or monitoring instrument. This arrangement requires complex manufacturing processes to fabricate. Because the Keith-type needle accommodates two electrical connectors in a side-by-side fashion, the needle is approximately twice as large as those typically used. The larger needle can cause undesirable tissue trauma.

U.S. Patent No. 5,795,178, issued on August 18, 1998 to Schilder et al., discloses a surgical electrode plug assembly for use with a heart electrode wire or other types of implantable wires intended for medical
applications. This assembly includes an electrode in the form of a conductive plug pin, which is in mechanical and electrical contact with the stripped end of the heart wire. This assembly also includes a spring-biased rigid sheath or sleeve that covers the aforesaid plug pin to insulate it from unintended electrical contact with its environment. The rigid sleeve is mounted on the electrode to permit reciprocating movement of the sleeve. Upon insertion of the plug pin of such an assembly into a device, such as a cardiac-pacing unit, the rigid sleeve moves backward, thereby exposing and allowing the plug pin to make contact with the cardiac pacing device. While this approach does a good job at protecting the conductive plug pin from accidentally contacting other surfaces, the device is somewhat complex and it does not completely insulate the conductive end of the heart electrode wire.

The electrode connector assembly of Osypka U.S. Patent No. 4,693,258, described above, has an insulative protective cap that can be used to cover its plug pin electrode, which is in electrical contact with the stripped end of the heart wire. This protective cap, while protecting the electrode from accidental transmission of impulses to the patient’s heart, is not resilient or spring-biased and, therefore, must be moved manually, which means that a separate step is required to either cover or uncover the electrode end. Additionally, the protective cap does not completely cover the electrode, i.e., a small portion of the electrode typically remains exposed.
U.S. Patent No. 5,241,957, issued on September 7, 1993 to Camps et al., discloses a temporary heart wire and an external connector that is designed to accommodate a straight Keith-type needle. This device also includes a protective sleeve that is adapted to slide over the outer surface of the wire to cover the end of the device's electrode and thereby prevent accidental transmission of impulses to the patient's heart. The device, however, is extremely complex, large and relatively bulky and, as with Osypka U.S. Patent No. 4,693,258, a separate step is required to manually cover or uncover the electrode end.

U.S. Patent No. 4,637,404, issued on January 20, 1987 to Gessman, discloses an apparatus and method for effecting cardiac pacing capture by use of an in-place catheter and wire electrode. This device includes a deformable sleeve that surrounds the wire electrode having uninsulated ends. While this sleeve serves to shield the wire electrode, its primary function is to allow the wire electrode to be advanced into a blood vessel in discreet increments. Furthermore, when the wire electrode has been so advanced, the uninsulated proximal end of the wire electrode that is intended for insertion onto a medical device is exposed and, therefore, susceptible to accidental electrical contact with its environment.

U.S. Patent No. 4,442,840, issued on April 17, 1984, to Wojciechowicz, Jr., discloses an electrical connector for a temporary pacing wire that is designed to accommodate a straight Keith-type needle. This
device provides a means of mounting the break away section of a Keith-type needle, which forms an electrode, into a non-conductive sheath. The sheath, with the electrode mounted therein, is then capable of being electrically connected to an extension cord adapter which is itself electrically connected to medical instrumentation. Thus, the sheath remains with the electrode as it is used with a medical device. This approach is disadvantageous because the resulting electrode is limited in use with medical devices that are particularly suited to accommodate the resulting electrical connector and corresponding extension cord. The patent further discloses that concept of using a small rubber plug to cover the open end of the connector. However, in the event that the rubber plug is not properly positioned on the open end, the electrode remains at least partially exposed to the environment.

U.S. Patent No. 5,904,587, issued on May 18, 1999, to Osypka et al., discloses an electrical connector with a plug and socket. This is essentially a recessed electrical connector. It has a complex design which increases manufacturing costs. As with Wojciechowicz, Jr. U.S. Patent No. 4,442,840, this connector also requires use with medical devices that are particularly adapted to accommodate the electrode assembly.

In view of the foregoing, there is a need for a simple, efficient and reliable mechanism for connecting the proximal ends of bipolar temporary pacing wires to a pacing or monitoring instrument. The mechanism should have few parts, be easy to manufacture and be consistent with minimal tissue
trauma to the patient. In addition, there is also a clear need for a simple, inexpensive and easy-to-use sub-component device that will fully protect exposed pacing wire connectors from inadvertent contact with undesirable electrically conductive surfaces.

Disclosure of the Invention

An object of this invention is to provide a novel and improved surgical electrical connector that can be connected to a medical instrument in a simple and time-saving manner.

Another objective of the invention is to provide an electrical connector that can be electrically connected directly to the socket of a pacing or monitoring instrument.

A further object of the invention is to provide an assembly requiring minimal tissue trauma during installation and simultaneously allowing for two electrical connections to be established with a pacing or monitoring instrument.

An additional object of the invention is to provide an electrical connector with partially insulated ends.

Still another object of the invention is to provide an electrical connector that is smaller in diameter than the Keith-type needle used to guide the connector to the outside of the body.
A further object of the invention is to provide an electrical connector with an insulating sheath that is simple in construction, economical to manufacture and easily adapted to existing electrodes.

Another object of the invention is to provide an electrical connector with an insulating sheath having a simple and efficient method of installation and operation.

An additional object of the invention is to provide an electrical connector with an insulating sheath that is resilient and can, therefore, be extended either manually or automatically to cover the entire length of the electrode when not connected to a medical device.

An additional object of the invention is to provide a pre-assembled electrical connector having an insulating sheath and which is adapted to accommodate stripped wire segments of the pacing wire electrodes.

With the foregoing objects in mind, the present invention relates to an electrical connector assembly in which a conductive lead adapted for connection to a source of electrical signals is folded over on itself. The present invention is especially suited for use in conjunction with a temporary cardiac pacing wire which includes an electrically conductive flexible wire having two elongated conductive sections at its proximal end. The conductive sections can be plugged into a pair of socket-like terminals of a pacing or monitoring instrument which generates electrical signals for stimulating,
pacing, sensing, monitoring or defibrillating the heart of a patient. One conductive section results from the distal end of a Keith-type needle that breaks away from the needle. This section can be plugged directly into one of the socket-like terminals of the pacing or monitoring instrument. The other conductive section is suitable for connecting to the other socket-like terminal when folded over on itself, or an adjacent insulated portion of wire to provide dimensional thickness necessary for an electrically secure connection. To facilitate its connection to the pacing or monitoring instrument in a plug-like fashion, this section may have a length which is more than ten times the diameter of the Keith-type needle, while having a maximum lateral dimension (e.g., a diameter in the case of a circular cross section) which is smaller than or equal to the diameter of the Keith-type needle.

In addition to the foregoing, in a preferred embodiment of the present invention, one or both of the connectors has an insulating resilient hollow sheath for insulating the connector. The hollow sheath can be used with either type of connector, i.e., the connector resulting from the broken Keith-type needle or the connector formed by the folded over portion of an elongated portion of the wire. The hollow sheath is resiliently moveable between an extended position, in which the entire connector is electrically insulated, and a retracted position that is assumed when the connector is plugged into a socket-like terminal of the pacing or monitoring instrument. The hollow sheath is made of material that, in addition to being electrically
insulating, has elastic memory such that when the connector is not plugged into the socket-like terminal, the sheath automatically moves into its extended position from its retracted position. Furthermore, the sheath has a flared portion for guiding insertion of a connector, as well as a narrow neck portion for frictionally gripping the end of the connector that is adjacent to the conductive flexible wire. The sheath also includes a corrugated section that is moveable, like an accordion, between an extended position and a retracted position and which has a pleated shape to facilitate such movement. In an alternative embodiment, the sheath also includes a coil spring located within the corrugated portion for urging the corrugated portion into its extended position from its retracted position when the connector is withdrawn from the socket-like terminal.

In another alternative embodiment, the sheath also includes a distal end portion having at least one deflectable flap for electrically insulating an end of the connector that is remote from the conductive flexible wire and an arcuate slit for facilitating deflection of the flap, or flaps, by the connector as it is plugged into the socket-like terminal of the pacing or monitoring instrument. The flap and slit can have a number of different configurations, including a plurality of flaps and slits. For instance, the sheath might have two flaps and a linear slit therebetween, or three flaps and three slits which form a "Y" shape therebetween. Also, the sheath could have four flaps and four slits which form a cross shape therebetween.
In another alternative embodiment, instead of having the two elongated sections described in the preferred embodiment, the conductive flexible wire has two partially elongated sections at its proximal end, each of which has a bare stripped wire end. The connectors of this alternative embodiment are formed by connector and sheath combinations having an insulating hollow sheath, in accordance with earlier embodiments, and a single-piece electrically conductive connector. The single piece connector has a base portion with a wire-receiving slot and an elongated portion for plugging into the socket-like terminal. The stripped wire end of each partially elongated section is inserted into the wire-receiving slot of the base of the single-piece connector. Furthermore, the wire-receiving slot may have different configurations such as an axially oriented linear slot or an L-shaped slot.

The invention has the advantage of ease of use without requiring additional pin-plugs or other assemblies. Also, the invention allows the use of needles, wires and connectors sized smaller than or equal to the size of existing Keith-type needles. The invention also provides electrical insulation for the connectors, especially during the time in which they are not plugged into the socket-like terminals of a pacing or monitoring instrument to prevent unintentional or accidental electrical contact with the environment. This electrical insulation of the connectors is automatically maintained because the insulating sheath is resilient and automatically expands in
accordion-like fashion into its extended position as the connector is withdrawn from the socket-like terminal. Furthermore, the sheath can be inexpensively manufactured and easily installed onto either type of connector.

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Brief Description of the Drawings

For a better understanding of the present invention, reference is made to the following detailed description of various exemplary embodiments considered in conjunction with the accompanying drawings, in which:

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FIG. 1 is a schematic illustration of a first embodiment of the invention showing a bipolar temporary pacing wire including a distal anchoring portion;

FIG. 1A is a cross-sectional view of the first embodiment taken along section line I-I and looking in the direction of the arrows;

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FIG. 1B is a cross-sectional view of the first embodiment taken along section line II-II and looking in the direction of the arrows;

FIG. 2 is a schematic, partially cross-sectioned illustration of the first embodiment inserted into a pacemaker;

FIG. 3 is a schematic, partially cross-sectioned illustration of a second embodiment of the invention inserted into a pacemaker;

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FIG. 4 is a schematic, partially cross-sectioned illustration of a third embodiment of the invention inserted into a pacemaker;
FIG. 5 is a schematic illustration of a fourth embodiment of the invention showing a bipolar temporary pacing wire including a distal anchoring portion;

FIG. 6 is a schematic, partially cross-sectioned illustration of the fourth embodiment inserted into a pacemaker;

FIG. 7 is a schematic, partially cross-sectioned illustration of a fifth embodiment of the invention inserted into a pacemaker;

FIG. 7A is a cross-sectional view of the fifth embodiment taken along section line III-III and looking in the direction of the arrows;

FIG. 8A is a partial schematic side view of a sixth embodiment of the invention shown prior to insertion into a pacemaker and having a resilient insulating sheath in an extended position;

FIG. 8B is a schematic, partially cross-sectioned view of the sixth embodiment with the resilient sheath in the extended position of FIG. 8A;

FIG. 9A is a partial schematic side view of the sixth embodiment with the resilient sheath in a retracted position;

FIG. 9B is a schematic, partially cross-sectioned view of the sixth embodiment with the resilient sheath in the retracted position of FIG. 9A;

FIG. 10 is a schematic, partially cross-sectioned illustration of the sixth embodiment shown inserted into a pacemaker and having resilient sheaths mounted on both electrodes, each sheath being shown in a retracted position.
FIG. 11 is a schematic, cross-sectioned side view of a seventh embodiment of the invention having a coil spring and an end flap;

FIG. 12A is an end view of the seventh embodiment showing a first configuration of the end flap;

FIG. 12B is an end view of the seventh embodiment showing a second configuration of the end flap;

FIG. 12C is an end view of the seventh embodiment showing a third configuration of the end flap;

FIG. 12D is an end view of the seventh embodiment showing a fourth configuration of the end flap;

FIG. 13 is a schematic cross-sectioned illustration of an eighth embodiment of the invention including a single-piece electrode with a wire receiving slot to accommodate the stripped wire end of a pacing wire and a retractable resilient insulating sheath with an end flap; and

FIG. 14 is a schematic cross-sectioned illustration of the eighth embodiment showing an alternative configuration for the wire receiving slot.

Best Mode for Carrying Out the Invention

Although the present invention is applicable to many different types of cardiac devices, it is especially suitable for use in conjunction with a bipolar temporary cardiac pacing wire. Accordingly, the present invention will be described below in connection with such a pacing wire.
As used herein, the term "distal" shall mean that portion of the pacing wire or element thereof which is remote from a source of electric signals located external to the patient's body. Conversely, the term "proximal" shall mean that portion of the pacing wire or element thereof which is in close proximity to the external source of electrical signals.

Referring to FIG. 1, a bipolar temporary cardiac pacing wire 10 includes a Keith-type breakaway needle 12 arranged at a proximal end of the pacing wire 10 and a curved needle 14 arranged at a distal end of the pacing wire 10, which also includes any type of suitable anchor 16 such as the one disclosed in U.S. Patent Application Serial No. 09/307,537, which was filed on May 7, 1999 by the assignee of the present application and which is incorporated herein by reference. The Keith-type needle 12, such as the one disclosed in U.S. Patent No. 4,010,756 issued on March 8, 1977 to DuMont et al., has a distal section 12a and a proximal section 12b, which is pointed for piercing the thoracic wall to lead the proximal end of the pacing wire 10 outside the chest cavity of a patient in accordance with a medical procedure well known in this field. The curved needle 14 is adapted to pierce the heart tissue and to attach the anchor 16 to the heart in accordance with another well-known medical procedure.

A pair of insulated, electrically conductive electrode wires 18, 20 extends between the distal and proximal ends of the pacing wire 10. The electrode wires 18, 20 are of the "lamp cord" type (i.e., they are arranged in
a side-by-side fashion as shown in FIG. 1A), each wire having a braided, multi-strand core of stainless steel and a surrounding layer of insulation made from polyethylene. Alternatively, the core of each wire could have a twisted construction with a surrounding layer of insulation made from polyethylene or any other suitable electric non-conducting material, such as silicon, polytetrafluoroethylene, or nylon.

At the distal end of the pacing wire 10 there are two electrodes 22, 24. The electrode 22 is electrically and mechanically connected to the electrode wire 18, but only mechanically connected to the electrode wire 20, which passes through the sleeve-like electrode 22 and is mechanically and electrically connected to the electrode 24. The electrodes 22, 24 have a conventional construction and are adapted to transmit electrical signals from one to the other for the purpose of stimulating, pacing, sensing, monitoring, or defibrillating the heart.

At the proximal end of the pacing wire 10 there are two connectors 26, 28. The connector 26 is mechanically and electrically connected to the electrode wire 20, but only mechanically connected to the electrode wire 18, which passes through the elongated, sleeve-like connector 26 and which is mechanically and electrically connected to the Keith-type needle 12 in a conventional manner. The other elongated, sleeve-like connector 28 is positioned on the electrode wire 18 intermediate to the connector 26 and the Keith-type needle 12. Unlike the connector 26, which
is electrically connected to the electrode wire 20, the connector 28 does not have to be electrically connected to either of the electrode wires 18, 20. However, the connector 28 may be electrically connected to the electrode wire 20, which could also be electrically connected to both of the connectors 26, 28. Each of the connectors 26, 28 extends circumferentially about the electrode wire 18 (see, for example, FIG. 1B) and is made from suitable electrically conductive material, such as stainless steel, for a purpose to be described hereinafter. While the connectors 26, 28 have a generally circular cross-sectional shape (as shown, for example, in FIG. 1B), they could have other cross-sectional shapes, such as oval, square, rectangular, etc.

Referring now to FIG. 2, the pacing wire 10 is shown adapted for use in connection with a pacemaker 30 having a pair of sockets 32, 34. As is typical of pacemakers like the pacemaker 30, a pair of spring-loaded clamps 36, 38 is mounted in the socket 32, one of which carries an electrical charge (either positive or negative) and the other of which is neutral (it does not carry either a positive charge or a negative charge). In a similar and typical fashion, a pair of spring-loaded clamps 40, 42 is mounted in the socket 34, one of which is neutral and the other of which carries an electrical charge opposite the charged clamp in the socket 32 (e.g., if the charged clamp in the socket 32 carries a negative charge, then the charged clamp in the socket 34 carries a positive charge, and vice versa).

In order to make an electrical connection within the socket 32
of the pacemaker 30, the Keith-type needle 12 is severed intermediate to its ends and the distal section 12a is inserted into the socket 32, while the proximal end 12b is discarded. Inside the socket 32, the distal section 12a is gripped between the clamps 36, 38 which have concave-shaped gripping surfaces so as to make good electrical and/or mechanical contact with the cylindrically-shaped distal section 12a and hence the electrode wire 18. Because the distal section 12a is made entirely of an electric-conducting material, such as stainless steel, electric-conducting contact within the socket 32 is ensured, regardless of which of the clamps 36, 38 is charged and regardless of how the distal section 12a is oriented relative to the charged clamp.

In order to make an electrical connection within the socket 34 of the pacemaker 30, the electrode wire 18 is first folded over onto itself such that the connectors 26, 28 are arranged in an abutting, juxtaposed relationship with respect to each other (i.e., they extend conjointly in parallel directions along their lengths). The folded portion containing the side-by-side connectors 26, 28 is then inserted, in a plug-like fashion, into the socket 34, where it is gripped between the clamps 40, 42 with the connector 26 in electric-conducting contact with the clamp 40 and the connector 28 in mechanical, but not electrical, contact with the clamp 42. To ensure good electrical and/or mechanical contact with the cylindrically-shaped connectors 26, 28, the clamps 40, 42 have concave gripping surfaces. Because the
connectors 26, 28 are in electric-conducting contact with each other, it does not matter which of the clamps 40, 42 is charged. More particularly, if, on the other hand, the clamp 40 is charged, then electric signals will flow from the pacemaker 30 to the electrode wire 20 via the clamp 40 and the connector 26. If, on the other hand, the clamp 42 is charged, then electric signals will flow from the pacemaker 30 to the electrode wire 20 via the clamp 42, the connector 28 and the connector 26.

Still referring to FIG. 2, the electrode wire 18 is flexible enough to form a loop 44 in the segment between the connector 28 and the distal section 12a of the Keith-type needle. In addition, the electrode wire 18 has sufficient flexibility to form a loop 46 in the segment between the connectors 26, 28. The loop 46 is small enough so as not to inhibit the folded section of the electrode wire (i.e., the plug-like section with the side-by-side connectors 26, 28) from being inserted into the socket 34. When arranged in the side-by-side manner depicted in FIG. 2, the cumulative size of the connectors 26, 28 is sufficiently large to avoid a poor (i.e., loose) grip by the clamps 40, 42, thereby promoting a good electrical connection between the pacemaker 30 and the electrode wire 20.

While the actual length of each of the connectors 26, 28 needs only be sufficient to assure secure insertion into the socket 34 of the pacemaker 30, preferably this length is about ten times or greater than ten times the diameter of the Keith-type needle 12. It is also preferable that each
of the connectors 26, 28 has a diameter which is smaller than or equal to that of the Keith-type needle 12. If the connectors 26, 28 do not have a circular cross-sectional shape, then their maximum lateral dimension would be smaller than or equal to the diameter of the Keith-type needle 12.

To fabricate the connector 26, a 300 series stainless steel tube (Type 304 Stainless Steel Hypodermic Needle Tubing Catalog No. T19XXTW available from Popper & Sons, Inc., New Hyde Park, New York) of 0.019", 0.037" inside diameter was used. The proximal end of the tube was reduced in diameter using a rotating Torrington swaging press (M/N 9194, made by Torrington Swager-Vaill End Forming Machinery Inc., Waterbury, Connecticut), while the distal end was left as its original diameter. The ends of the electrode wires 18, 20 were separated for a length sufficient to allow for the electrode wire 18 to extend on for attachment to the distal section 12a of the Keith-type needle 12. The electrode wire 20 was cut and the insulation removed from a small length of its end. Both of the electrode wires 18, 20 were then inserted into the distal opening (i.e., the larger one) of the swaged tube until the uninsulated end of the electrode wire 20 was completely inside the distal opening of the tube. The end of the tube containing the distal opening was then swaged to make a secure electrical connection between the uninsulated end of the electrode wire 20 and the tube. While the swaging operation was carried out using a Torrington swaging press, a multi-collet vice could also be used to achieve a similar result.
The connector 28 was fabricated in a similar manner. More particularly, the electrode wire 18 was placed in a 0.019" inside diameter 300 stainless steel tubing (Popper & Sons, Inc.). The electrode wire 18 and the tubing wire then placed in a Torrington swaging press and swaged until the diameter of the tubing was reduced sufficiently to assure a secure circumferential fit around the electrode wire 18 without compromising the wire’s insulation.

What follows is a description of various alternate embodiments of the present invention. In describing these embodiments, elements corresponding to elements described above in connection with the embodiment of FIGS. 1 and 2 will be described by corresponding reference numerals increased by one hundred, two hundred, three hundred, four hundred, five hundred, six hundred and seven hundred respectively. The alternate embodiments are constructed and operate in the same manner as the embodiment of FIGS. 1 and 2, unless otherwise specified.

With reference to FIG. 3, the distal section 112a of a severed Keith-type needle has an end 148 which is exposed in that it extends outwardly from the socket 132 of the pacemaker 130. Similarly, the connectors 126, 128 have ends 150, 152, respectively, which are exposed in that they extend outwardly from the socket 134 of the pacemaker 130. In order to prevent shorting or shocking problems, the exposed end 148 of the distal section 112a is provided with electric insulation 154, while the exposed
ends 150, 152 of the connectors 126, 128 are also provided with electric insulation 156, 158, respectively.

Referring now to FIG. 4, the socket 234 of the pacemaker 230 (such as a Medtronic Model No. 5375) houses the clamps 240, 242, both of which carry an electric charge. In this embodiment, unlike the embodiment of Figures 1 and 2, the connector 226 can receive electric signals from either of the clamps 240, 242, thereby making the connector 28 shown in Figures 1 and 2 expendable. Thus, although the electrode wire 218 still has a folded, plug-like portion, the connector 226 simply extends alongside the insulation on an abutting section of the electrode wire 218. As depicted in Figure 4, electric signals would be transmitted from the pacemaker 230 to the electrode wire 220 via the clamp 240 and the connector 226. However, electric signals from the pacemaker 230 could also be transmitted to the electrode wire 220 if the connector 226 were in contact with the clamp 242, rather than the clamp 240.

The embodiment of FIGS. 5 and 6 is especially useful with Keith-type needles having a diameter that is too small to be securely gripped by the clamps of a pacemaker like the Medtronic Model No. 5375. In this embodiment, the electrode wire 318 has a third sleeve-like connector 360, in addition to the connectors 326, 328. In order to make an electrical connection in the socket 332 of the pacemaker 330, the distal section 312a of a severed Keith-type needle is folded over onto the connector 360 in much the same
way that the connectors 326, 328 are folded over onto each other, thereby forming a loop 362 in the segment of the electrode wire 318 between the distal section 312a and the connector 360. Like the side-by-side connectors 326, 328 which are inserted together into the socket 334, the distal section 312a and the connector 360 are inserted together, in plug-like fashion, into the socket 332, the loop 362 being small enough so as not to inhibit such insertion. Once they have been fully inserted into the socket 332, the distal section 312a makes electrical contact with the clamp 338, while the connector 360 makes electrical contact with the clamp 336. Of course, this arrangement could be reversed, whereby the distal section 312a would make electrical contact with the clamp 336, while the connector 360 would make electrical contact with the clamp 338. It should be noted that the connector 360 may or may not be electrically connected to the electrode wire 318 to which it is mechanically attached about the circumference thereof.

In the embodiment of FIGS. 7 and 7A, the electrode wires 418, 420 have a coaxial construction (see FIG. 7A). Except for the sizes and shapes of the connectors 426, 428, the other components of the pacing wire 410 are essentially the same as their counterparts in the embodiment of FIG. 2.

The following discussion describes the alternative embodiments of the present invention that include a resilient insulating sheath. With reference to FIGS. 8A, 8B, 9A and 9B, a sixth embodiment of the present
invention includes a resilient insulating sheath 564 having a hollow, generally
cylindrical shape and which is sized and shaped to snugly, but removably,
receive the folded portion of the electrode wire 518 containing the side-by-
side connectors 526, 528, which is described above in connection with FIG.
2 and is hereinafter referred to as a plug assembly 566. It should be noted
that the resilient insulating sheath 564 can also receive the distal section of
the Keith-type needle (see, e.g., FIG. 10) that forms another electrode of the
pacing wire 510, as was also described above in connection with FIG. 2.

The insulating sheath 564 has a funnel shaped or flared portion
568, with a wider open end 570, and an adjacent neck portion 572 of uniform
inner diameter. The purposes served by the flared portion 568 and the neck
portion 572 will be described hereinafter. The insulating sheath 564 also has
a corrugated section 574 which is adjacent to the neck portion 572. The
corrugated section 574 has a pleated shape, i.e., it has alternating constricted
and distended segments 578, 580, respectively, which facilitates the
accordion-like collapse and expansion of the elongated section 574 between
its retracted and expanded positions, as will be described in further detail
hereinafter. Lastly, the insulating sheath 564 also has a short distal end
portion 580 that extends co-axially beyond the end of the corrugated section
574 and has an open end 582.

The insulating sheath 564 normally assumes an extended
position, shown in FIGS. 8A and 8B, in which the insulating sheath 564
covers and, thereby, insulates the entire length of the plug assembly 566, including the connectors 526, 528. Referring now to FIGS. 9A and 9B, the insulating sheath 564 can be moved from its extended position to a retracted position, in which the corrugated section 574 is collapsed or compressed along its longitudinal axis like an accordion to about half of its full length. As can be seen in FIGS. 9A and 9B, when the insulating sheath 564 is in its retracted position, the side-by-side connectors 526, 528 of the plug assembly 566 protrude out from the open end 582 of the distal end portion 580 and are, thus, sufficiently exposed to make electrical contact with the terminal of the pacemaker 530 (see, e.g., FIG. 10) when inserted into the socket 534 thereof.

The insulating sheath 564 is fabricated in one piece by blow molding, a well-known process. Furthermore, it is made of flexible, resilient material such as rubber, silicone, polyurethane, nylon, polyethylene or any similar material. The material used to make the insulating sheath 564 can be of medical grade, but this is not necessary since the insulating sheath 564 will not reside within the body of the patient, but rather, will always be external.

The dimensions and configuration of the insulating sheath 564 correspond to the dimensions of the plug assemblies of the pacing wire 510. The thickness of the walls of all portions and sections of the insulating sheath is approximately 0.02". The inner diameter of the open end 570 of the flared portion 568 is approximately 0.100", while the other end, adjacent to the neck portion 572, is approximately 0.030". The wider diameter of the open end 570
of the flared portion 568 is intended to facilitate insertion of the plug assembly 566 therein, as will be described in greater detail hereinafter. The inner diameter of the neck portion 572 is also 0.030", which is slightly less than the total combined thickness of the two side-by-side connectors 526, 528 of the plug assembly 566 (approximately 0.045"), which ensures a snug fit therebetween. The inner diameters of the constricted and distended segments 576, 578 of the corrugated section 574 are approximately 0.055" and 0.100", respectively. This configuration of the corrugated section 574 permits its collapse and expansion, while at the same time allowing the side-by-side connectors 526, 528 to move freely and slidably therein. The inner diameter of the distal end portion 580 of the insulating sheath 564 is approximately 0.055", i.e., the same as for the constricted segments 576 of the corrugated section 574. The foregoing dimensions can be varied to accommodate different flexibilities of the material used to make the insulating sheath 564, as well as to accommodate pacing wires 510 and plug assemblies 566 having different dimensions than those described herein.

The method of installing the insulating sheath 564 onto the plug assembly 566 will now be described. Initially, the plug assembly 566 is formed by folding the electrode wire 518 over onto itself (as described above in connection with the use of the pacing wire 510 with a pacemaker 530), thereby forming the loop 546 and aligning the connectors 526, 528. The plug assembly 566 is then inserted, loop 546 first, through the flared portion 568
and into the insulating sheath 564 until the entire length of the plug assembly 566 is covered by the insulating sheath 564. During the foregoing installation process, the plug assembly 566 should be held at the part thereof that is remote from the loop 546, i.e., where the wires 518, 520 meet the connectors 526, 528, while the insulating sheath 564 is held by its neck portion 572 and slid onto the connectors 526, 528 until the flared portion 568 abuts against the user's fingers. The insulating sheath 564 is held in place on the electrode assembly by frictional contact between the neck portion 572 of the insulating sheath 564 and the connectors 526, 528. When the insulating sheath 564 is properly and completely installed, its distal end portion 580 will extend beyond and cover the loop 546 of the electrode assembly and the flared portion 568 will completely cover the connectors 526, 528 and a small portion of the wires 518, 520 (see FIGS. 8B and 9B).

As shown in FIG. 10, to connect the plug assembly 566 of the pacing wire 510 to the pacemaker 530, the plug assembly 566 is inserted, loop 546 first, into the socket 534, which causes the insulating sheath 564 to move in accordion-like fashion to its retracted position as follows. As the plug assembly 566 is inserted into the socket 534, the distal end portion 580 of the insulating sheath 564 abuts the exterior wall of the pacemaker 530. As the plug assembly 566 is further inserted into the socket 534, the constricted and distended segments 576, 578 of the corrugated section 574 fold upon one another (i.e., they collapse in an accordion-like fashion), thereby compressing
the corrugated section 574 along its longitudinal axis and exposing the connectors 526, 528 so that they can make electrical contact with the terminal of the pacemaker 530 inside the socket 534. When the plug assembly 566 is withdrawn from the socket 534, the insulating sheath 564 automatically returns to its extended position because it is made of resilient material. If made of a less resilient material, the insulating sheath 564 could be manually moved back to its extended position.

With reference now to FIG. 11, a seventh embodiment of the present invention includes an insulating sheath 664 having a coil spring 684 fitted within the corrugated section 672. When the insulating sheath 664 cannot automatically return to its extended position, possibly because the materials used are not sufficiently resilient or its dimensions do not permit sufficient flexibility and resilience, the coil spring 684 can be fitted within the corrugated section 674 to provide the force necessary to return the insulating sheath 664 to its extended position without the use of manual force.

Referring still to FIG. 11, the insulating sheath 664 of the seventh embodiment is also provided with a distal end portion 680 having a deflectable end flap 686. Where the insulating sheath 664 is installed onto the distal section 512a of the Keith-type needle 512 (as shown in FIG.10), the distal section 512a of the Keith-type needle 512 may require additional protection since, unlike the loop 546 of the plug assembly 566, it is not insulated. To provide such additional insulative protection, the distal end
portion 680 of the insulating sheath 664 is provided with the deflectable end flap 686. The end flap 686 has a slit 688 that facilitates deflection of the end flap 686 when the distal end 512a of the Keith-type needle 12 moves past the end flap 686, through the distal end portion 680 and out of the open end 682 of the distal end portion 680 of the insulating sheath 664. The insulating sheath 664 having an end flap 686 at its distal end portion 680 is also useful where the loop 646 of the plug assembly (not shown), unlike the one shown in Figures 9A and 9B, is not insulated and, therefore, requires additional insulating protection.

In addition, with reference particularly to FIGS. 12A-12D, the slit 688 of the end flap 686 can have a number of different shapes and configurations. For example, the end flap might have a semicircular slit 688a located around the edge of the end flap 686, as shown in FIG. 12A, or a linear slit 688b that bisects the end flap 686, as shown in FIG. 12B. Alternatively, the end flap 686 may have a plurality of slits 690a, preferably three in number, that form a “Y” shape and divide the end flap 686 into parts, as shown in FIG. 12C. The end flap 686 might, instead, have a plurality of slits 690b, preferably four in number, that form a cross or plus sign (“+”) shape and also divide the end flap 686 into parts, as shown in FIG. 12D. The shape and configuration of the slit 688a, 688b or plurality of slits 690a, 690b that is provided on the end flap 686 might be determined by the flexibility and resilience of the material used to manufacture the insulating sheath 664 or by
the aesthetic preferences of the users.

Referring now to FIGS. 13 and 14, an eighth embodiment of the present invention includes a single-piece electrode 792 that is pre-assembled with an insulating sheath 764 having an end flap 786. As will be discussed further hereinafter, this alternative embodiment is adapted for use with pacing wires that have stripped wire ends (not shown) rather than the connectors 526, 528 shown in the embodiments discussed above. The single-piece electrode 792 has a base portion 794 that is sized and shaped to maintain frictional contact with the neck portion 772 of the insulating sheath 764. The single-piece electrode 792 also has an elongated portion 796 that is sized and shaped to be inserted into the socket of the pacemaker (not shown in FIGS. 13 and 14, but see FIGS. 2 and 10).

As shown in FIG. 13, an axially oriented wire receiving slot 798a is provided on the base portion 794 of the single-piece electrode 792 to securely receive the stripped wire end (not shown) of a pacing wire (also not shown). To assemble this embodiment, the corrugated section 774 of the insulating sheath 764 and the elongated portion 796 of the single piece electrode 792 are securely held while the flared and neck portions 768, 772 are slid along the electrode 792, in the direction of the elongated portion 796, to expose the base portion 794 and wire receiving slot 798a. The stripped wire end is then inserted into the wire receiving slot 798a at an angle approximately perpendicular to the longitudinal axis of the slot 798a and the
electrode 792. To secure the stripped wire end in electrical contact with the electrode 792, the slot 798a may be equipped with various conventional securing means, such as being elastically biased and/or designed to wedge the stripped wire in place, or incorporating a detent or barbed configuration to prevent the stripped wire from being axially withdrawn. Once the stripped wire is securely inserted into the wire receiving slot 798a, the flared and neck portions 768, 772 of the insulating sheath 764 are manually moved back into the position covering the base portion 794 of the electrode 792.

FIG. 14 shows a single-piece electrode 792 having a wire receiving slot 798b with an angular shape and which is utilized in substantially the same manner as described above in connection with FIG. 13. The insulating sheath 764 is also configured and operated in substantially the same manner as described above in connection with FIG. 13.

It will be understood that the embodiments described herein are merely exemplary and that a person skilled in the art may make many variations and modifications without departing from the spirit and scope of the invention. All such variations and modifications are intended to be included within the scope of the invention as defined in the appended claims.
Claims:

1. An electrical connector for a cardiac device, comprising wire means having a distal end and a proximal end; and connecting means for electrically connecting said wire means to a cardiac device, said connecting means including at least one electrically conductive connector disposed about said wire means intermediate said distal and proximal ends thereof and a folded over section of said wire means which cooperates with said at least one connector to form a plug assembly having a dimensional thickness sufficient to permit said assembly to be plugged into an electrical terminal socket of the cardiac device.

2. An electrical connector according to Claim 1, wherein said at least one connector includes a first connector and a second connector, one of said first and second connectors being located on said folded over section of said wire means, and said first and second connectors cooperating with each other and with said wire means to form said plug assembly.

3. An electrical connector according to Claim 2, wherein said at least one electrical connector includes a third connector, and wherein said wire means includes a fourth electrically conductive connector disposed at said proximal end thereof, said fourth connector cooperating with said third connector and with another folded over section of said wire means to form another plug assembly having a dimensional thickness sufficient to permit
said another assembly to be plugged into another electrical terminal socket of the cardiac device.

4. An electrical connector according to Claim 1, wherein said at least one electrical connector includes one connector only, said one connector cooperating with an electrically insulated portion of said folded over section of said wire means to form said plug assembly.

5. An electrical connector according to Claim 1, further comprising insulating means for electrically insulating said plug assembly, said insulating means being movable from an extended position, in which said plug assembly is electrically insulated by said insulating means, to a retracted position that is assumed when said plug assembly is plugged into the electrical terminal socket of the cardiac device, thereby allowing electrical connection between said connector and the cardiac device.

6. An electrical connector according to Claim 5, wherein said insulating means is resiliently movable between its said extended and retracted positions.

7. An electrical connector according to Claim 6, wherein said insulating means collapses in accordion-like fashion as it moves from its said extended position to its said retracted position.

8. An electrical connector according to Claim 7, wherein said insulating means expands in accordion-like fashion as it moves from its said retracted position toward its said expanded position.
9. An electrical connector according to Claim 8, wherein said insulating means is made from material having elastic memory, whereby said insulating means automatically moves from its said retracted position toward its said extended position when said plug assembly is unplugged from the electrical terminal socket of the cardiac device.

10. An electrical connector according to Claim 8, wherein said insulating means includes a coil spring which automatically urges said insulating means from its said retracted position toward its said extended position when said plug assembly is unplugged from the electrical terminal socket of the cardiac device.

11. An electrical connector for a cardiac device, comprising wire means having a first electrode at a distal end of said wire means, a second electrode at said distal end of said wire means, a first electrically conductive wire electrically connected to said first electrode and extending from said first electrode to a proximal end of said wire means, and a second electrically conductive wire electrically connected to said second electrode and extending from said second electrode to said proximal end of said wire means; and connecting means for electrically connecting said wire means to a cardiac device, said connecting means including a folded over section of said wire means, a first connector, located at said proximal end of said wire means, for electrically connecting said first wire to a source of electric signals, and a second connector, located between said proximal and distal ends of said wire
means, for electrically connecting said second wire to a source of electric signals, said second connector being in the form of a sleeve and being mechanically connected to said first and second wires but electrically connected to said second wire only, and said first wire including said folded over section.

12. An electrical connector according to Claim 11, wherein said first wire is sufficiently flexible to permit a portion thereof to be folded over into abutment with said second connector to form a plug assembly having a dimensional thickness sufficient to permit said assembly to be plugged into an electrical terminal socket.

13. An electrical connector according to Claim 12, wherein said first connector includes a distal portion of a severed Keith-type needle.

14. An electrical connector according to Claim 13, wherein said Keith-type needle has an outside diameter and said second connector has a length which is at least about ten times said diameter of said Keith-type needle.

15. An electrical connector according to Claim 14, wherein said second connector has a maximum lateral dimension which is not greater than said diameter of said Keith-type needle.

16. An electrical connector according to Claim 13, wherein said connecting means further includes a third connector which is in the form of a sleeve and which is mechanically connected to said first wire, said third
connector being positioned on said first wire such that said third connector cooperates with said second connector to form said plug assembly.

17. An electrical connector according to Claim 16, wherein said third connector is electrically connected to said second wire.

18. An electrical connector according to Claim 16, wherein said third connector is not electrically connected to said second wire.

19. An electrical connector according to Claim 16, wherein said second and third connectors extend circumferentially about said first wire, said first wire extending longitudinally through said second and third connectors.

20. An electrical connector according to Claim 16, wherein said Keith-type needle has an outer diameter and each of said second and third connectors has a length which is at least about ten times said diameter of said Keith-type needle and a maximum lateral dimension which is not greater than said diameter of said Keith-type needle.

21. An electrical connector according to Claim 16, wherein said second connector has an electrically-insulated distal end, said third connector has an electrically-insulated proximal end, and said distal portion of said Keith-type needle has an electrically-insulated distal end.

22. An electrical connector according to Claim 16, wherein said connecting means further includes a fourth connector which is in the form of a sleeve and which extends circumferentially about said first wire, said fourth
connector being positioned on said first wire such that said fourth connector abuts said distal portion of said Keith-type needle when another section of said wire means is folded over, whereby said fourth connector cooperates with said distal portion of said Keith-type needle to form another plug assembly adapted to be plugged into another electrical terminal socket.

23. An electrical connector according to Claim 22, wherein said fourth connector is electrically connected to said first wire.

24. An electrical connector according to Claim 22, wherein said fourth connector is not electrically connected to said first wire.

25. An electrical connector according to Claim 22, wherein said Keith-type needle has an outer diameter and each of said second, third, and fourth connectors has a length which is at least ten times said diameter of said Keith-type needle and a maximum lateral dimension which is not greater than said diameter of said Keith-type needle.

26. An electrical connector according to Claim 11, wherein said first and second wires are arranged in a side-by-side fashion relative to each other.

27. An electrical connector according to Claim 11, wherein said first and second wires are arranged coaxially relative to each other.

28. An electrical connector according to Claim 11, further comprising first insulating means for electrically insulating one of said first and second connectors, said first insulating means being movable from an extended
position, in which said connector is electrically insulated by said first insulating means, to a retracted position that is assumed when said one connector is plugged into an electrical terminal socket of the cardiac device, thereby allowing electrical connection between said one connector and the cardiac device.

29. An electrical connector according to Claim 28, further comprising second insulating means for electrically insulating the other of said first and second connectors, said second insulating means being movable from an extended position, in which said other connector is electrically insulated by said second insulating means, to a retracted position that is assumed when said other connector is plugged into another electrical terminal socket of the cardiac device, thereby allowing electrical connection between said other connector and the cardiac device.

30. An electrical connector according to Claim 29, wherein each of said first and second insulating means is resiliently movable between its said extended position and its said retracted position.

31. An electrical connector according to Claim 30, wherein each of said first and second insulating means collapses and expands in accordion-like fashion as it moves between its said extended and retracted positions.

32. An electrical connector according to Claim 31, wherein at least one of said first and second insulating means is made from material having elastic memory, whereby said at least one of said first and second insulating
means automatically moves from its said retracted position toward its said extended position when its corresponding connector is unplugged from the cardiac device.

33. An electrical connector according to Claim 32, wherein both of said first and second insulating means are made from material having elastic memory, whereby said first and second insulating means automatically move from their said retracted positions toward their said extended positions when their corresponding connectors are unplugged from the cardiac device.

34. An electrical connector according to Claim 31, wherein at least one of said first and second insulating means includes a coil spring which automatically urges said at least one insulating means from its said retracted position toward its said extended position when its corresponding connector is unplugged from the cardiac device.

35. An electrical connector according to Claim 34, wherein each of said first and second insulating means includes a coil spring, whereby both of said first and second insulating means are automatically urged from their said retracted positions toward their said extended positions when their corresponding connectors are unplugged from the cardiac device.

36. A temporary pacing wire, comprising a first electrode at a distal end of said pacing wire; a second electrode at said distal end of said pacing wire; a first electrically conductive wire electrically connected to said first electrode and extending from said first electrode to a proximal end of said
pacing wire; a second electrically conductive wire electrically connected to said second electrode and extending from said second electrode to said proximal end of said pacing wire; first connecting means, located at said proximal end of said pacing wire, for electrically connecting said first wire to a source of electric signals; and second connecting means, located at said proximal end of said pacing wire, for electrically connecting said second wire to a source of electric signals, said second connecting means including a connector which is in the form of a sleeve and which is mechanically connected to said first and second wires but electrically connected to said second wire only, said first wire being sufficiently flexible to permit a portion thereof to be folded over into abutment with said connector to form a plug assembly having a dimensional thickness sufficient to permit said plug assembly to be plugged into an electrical terminal socket.

37. A temporary pacing wire according to Claim 36, further comprising insulating means for electrically insulating at least one of said first and second connecting means, said insulating means being resiliently movable from an extended position, in which said at least one of said connecting means is electrically insulated by said insulating means, to a retracted position, in which said at least one of said connecting means is not electrically insulated by said insulating means.
38. A temporary pacing wire according to Claim 37, wherein said at least one of said connecting means includes both said first connecting means and said second connecting means.

39. An electrical connector for a cardiac device, comprising wire means, connecting means for electrically connecting said wire means to the cardiac device, and resilient insulating means for electrically insulating said connecting means, said insulating means being collapsible in accordion-like fashion such that it is movable between an extended position, in which said connecting means is electrically insulated by said insulating means, and a retracted position that is assumed when said connector is connected to the cardiac device to allow electrical connection between said connecting means and the cardiac device.

40. An electrical connector according to Claim 39, wherein said insulating means is made from material having elastic memory such that when said connecting means is not connected to the cardiac device, said insulating means automatically moves toward its said extended position from its said retracted position.

41. An electrical connector according to Claim 40, wherein said insulating means includes a hollow sheath disposed substantially coaxially about said connecting means, said sheath having a flared end for guiding the insertion of said connecting means, a narrow neck portion adjacent to said flared end for frictionally gripping an end of said connecting means that is
adjacent to said wire means, and a corrugated section between said neck portion and an opposite end of said sheath, said corrugated section expanding and contracting in accordion-like fashion as said insulating means moves between its said extended position and its said retracted position.

42. An electrical connector according to Claim 41, wherein said corrugated section of said sheath has a pleated shape, thereby facilitating the expansion and contraction of said corrugated section as said insulating means moves between its said extended position and its said retracted position.

43. An electrical connector according to Claim 42, wherein said sheath includes a coil spring inside said corrugated section for facilitating the expansion of said sheath as said insulating means moves toward its said extended position from its said retracted position.

44. An electrical connector according to Claim 40, wherein said opposite end of said sheath includes at least one deflectable flap for electrically insulating an end of said connecting means that is remote from said wire means, said at least one flap being deflectable by said end of said connecting means as said insulating means moves from its said extended position to its said retracted position, thereby allowing electrical connection between said connecting means and the cardiac device.

45. An electrical connector according to Claim 44, wherein said at least one flap includes a single flap.
46. An electrical connector according to Claim 44, wherein said at least one flap includes a plurality of flaps.

47. An electrical connector according to Claim 39, wherein said wire means includes a first electrode at a distal end of said wire means, a second electrode at said distal end of said wire means, a first electrically conductive wire electrically connected to said first electrode and extending from said first electrode to a proximal end of said wire means, and a second electrically conductive wire electrically connected to said second electrode and extending from said second electrode to said proximal end of said wire means; and wherein said connecting means includes a folded over section of said wire means, a first connector, located at said proximal end of said wire means, for electrically connecting said first wire to a source of electric signals, and a second connector, located between said proximal and distal ends of said wire means, for electrically connecting said second wire to a source of electric signals, said second connector being in the form of a sleeve and being mechanically connected to said first and second wires but electrically connected to said second wire only, and said first wire including said folded over section which cooperates with said second connector to form a plug assembly having a dimensional thickness sufficient to permit said assembly to be plugged into an electrical terminal socket.
48. An electrical connector according to Claim 47, wherein said insulating means includes a first hollow sheath disposed substantially coaxially about said first connector and a second hollow sheath disposed substantially coaxially about said plug assembly, each of said first and second sheaths having a corrugated section which expands and contracts in accordion-like fashion as said insulating means moves between its said extended position and its said retracted position.

49. An electrical connector according to Claim 48, wherein said first connector includes a distal portion of a severed Keith-type needle.

50. An electrical connector according to Claim 48 or 49, wherein said connecting means further includes a third connector which is in the form of a sleeve and which is mechanically connected to said first wire, said third connector being positioned on said first wire such that said third connector cooperates with said second connector to form said plug assembly and said second and third connectors extend circumferentially about said first wire, said first wire extending longitudinally through said second and third connectors.