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Williamson

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[54] **NONPOLARIZABLE MUSCLE STIMULATING ELECTRODE**

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[52] **U.S. Cl.** .... **128/418,** 128/419 P
[51] **Int. Cl.** **A61n 1/04**
[58] **Field of Search** .... 128/404, 405, 410, 128/411, 416, 418, 419 C, 419 E, 419 P

[56] **References Cited**

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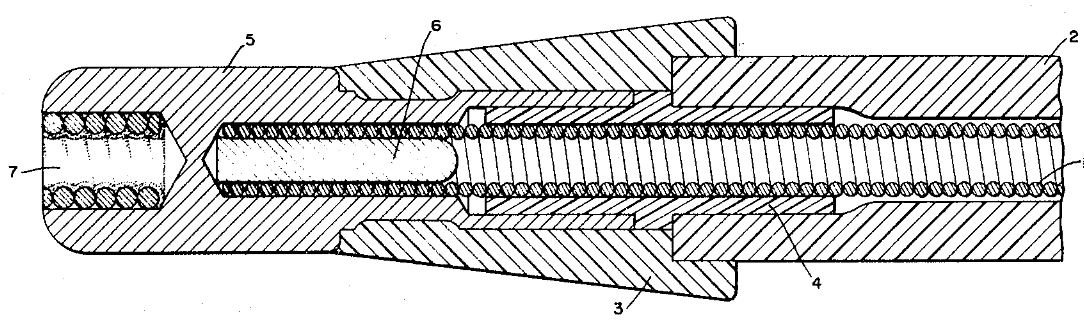
[57] **ABSTRACT**

A nonpolarizable muscle stimulating electrode is formed of a platinum black insert in a housing of inert electrode metal, preferably titanium. It features high current density at low pulse voltage.

7 Claims, 2 Drawing Figures



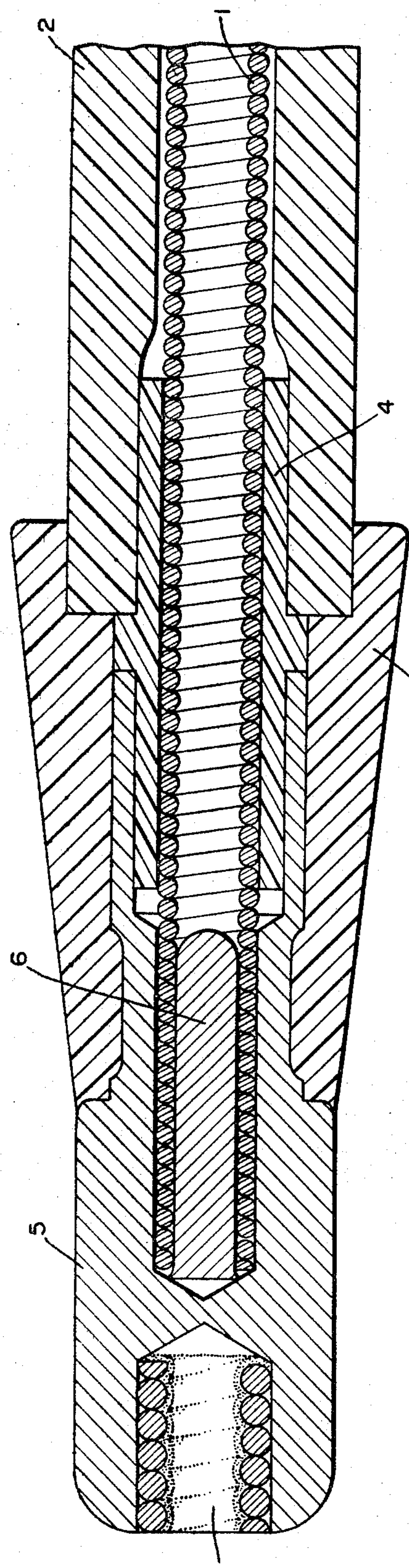


FIG. 1

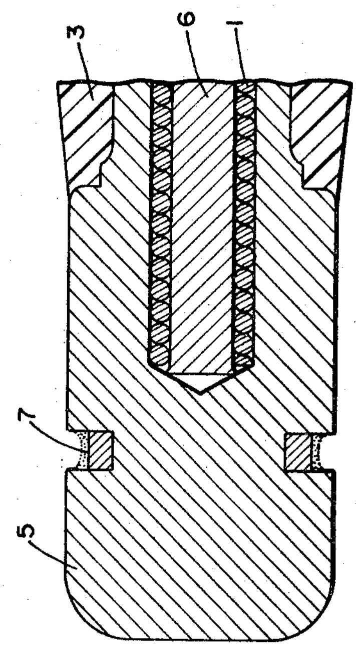


FIG. 2

NONPOLARIZABLE MUSCLE STIMULATING ELECTRODE

BACKGROUND OF THE INVENTION

The electrical stimulation of muscular contraction, such as encountered in cardiac pacemaking, generally makes use an electrode for contacting the muscle. In cardiac pacemaking for instance, the electrode may be surgically implanted in the myocardium or, more commonly, it is inserted pervenously into the right ventricle into contact with the endocardium.

The stimulation of muscular contraction generally requires the application of an electrical pulse which exceeds a certain threshold current density. The voltage of the pulse must be sufficient to attain this current density but should be as low as possible in order to conserve energy and minimize the running down of the batteries generally employed.

The nature of the electrical circuit established by the stimulating electrode can generally be represented by a capacitor and a resistor in parallel. The application of each pulse causes charging of the capacitor; after the end of the pulse the discharge of the capacitor results in a current reversal of greater or lesser amplitude and duration depending upon the relative magnitudes of the resistor and capacitor. It is generally desirable that the discharge current following termination of the pulse be of short duration.

Thus, it is desirable that the resistance component be small, such that the pulse is carried for the most part by the resistance component. Such electrodes are commonly called "nonpolarizable."

BRIEF DESCRIPTION OF THE INVENTION

The present invention provides an electrode for muscle stimulation characterized by a current density many times greater than those achieved by presently known electrodes, yet capable of being energized by an electrode-electrolyte interface voltage of the order of one volt or less. In general this invention features a platinum electrode which has preferably been platinized to develop a coating of platinum black, contained in a second electrode housing of suitable electrode metal which is compatible with platinum such as titanium. With such an electrode the current is delivered to the muscle electrolyte almost exclusively through the platinum black portion. As this may be quite small in size, extremely high current densities are obtained. On the other hand if for any reason the functioning of the platinum black should be impaired, the surrounding electrode body is still effective for stimulation.

DETAILED DESCRIPTION

This invention is described below in detail with respect to the preferred embodiments wherein reference is made to the accompanying drawings in which:

FIG. 1 is a longitudinal cross-section of the tip portion of a heart pacer electrode illustrating one preferred embodiment of this invention, and

FIG. 2 is a longitudinal cross-section of the tip portion of a heart pacer electrode illustrating a second preferred embodiment.

The transverse cross-sections are circular.

Experiments with a variety of metals including Elgiloy, commercially pure titanium, tantalum, and platinum clearly indicate that the amount of voltage necessary to drive a given current through an electrode in vitro varies greatly between these metals. It has also been found that if platinum is coated with platinum-black according to the well known "platinizing" technique, the characteristics of the surface are further improved such that a given current can be passed across the electrode-electrolyte interface at even lower voltage.

The improved electrode, according to the present invention, utilizes these discoveries in an electrode design of a standard shape which is known to be readily implantable by the pervenous technique in the tip of the right ventricle.

One form of this electrode is shown in FIG. 1. The conductor from the heart pacer to the electrode is shown at 1 and is of the coiled Elgiloy lead construction which has now become standard with many manufacturers. The lead is insulated by Silastic tubing 2 which is connected to and molded to the metal housing 5 by molded Silastic 3. A molded Silastic flexure sleeve 4 provides protection for the lead against sharp bends where it leaves the tip. The housing 5 can be made of any metal suitable for such an electrode in consideration of its corrosion and electrical properties, but commercially pure titanium is the metal of choice. The housing 5 is held onto the wire coil by staking against staking slug 6, a small piece of the same metal of which the lead is made which is placed inside the coil to give support to the staking operation.

Inserted into a hole at the end of the housing is a piece of platinum 7. This platinum can be inserted by electro-plating, by pressing in a platinum sleeve, or as is shown in the illustration by pressing in a tight-fitting coil of platinum wire. One of the choices of titanium for the electrode tip is that platinum and titanium do not form a galvanic couple and will not corrode in the presence of body fluids. After the lead has been completed as shown, it is cleaned and immersed in a platinizing solution consisting of 3.5 percent chloroplatinic acid and 0.005 percent lead acetate. An anode of inert metal is provided, such as platinum. A sufficient current is passed through the cell thus formed so that fine bubbles are just visible from the electrode (cathode). After a few minutes a black deposit will form over the entire electrode. The electrode is then washed gently in distilled water and the platinum-black removed from the outer titanium surface with a soft absorbent paper or by any other convenient means, leaving the platinum-black, of course, in the hole at the end.

Measurements in vitro on an electrode of this type indicate that at a total current of 7.6 milliamperes the current density at the hole (whose area is 0.0137 cm^2) should be about 555 milliamperes per square centimeter. This is to be compared with 24 milliamperes per square centimeter if the entire tip surface of 0.32 cm^2 was conducting. Experiments were conducted in which the titanium surface of the housing 5 was insulated from the solution by a thick layer of enamel, and from such experiments it was established that the principal electrical current carrier is the platinum-black in the hole.

Another electrode design is shown in FIG. 2. In this design a thin slot, for instance 0.25 millimeters, has been cut in the titanium housing and a platinum ring staked in place well below the surface of the titanium. This electrode is then platinized as described above and the black coating removed from the titanium, taking care not to remove it from the slot. With a single slot in a tip of 2.25 millimeters diameter, the caculated area of the groove is 0.018 cm^2 and the current density at 7.6 milliamperes would be calculated as 422 milliamperes per square centimeter.

DISCUSSION

An advantage to the design of FIG. 2 is that it is much less dependent upon its position in the right ventricle of the heart. FIG. 1 would be most efficient if the hole at the end could be reliably positioned in contact with the inner wall of the myocardium. Since this is not necessarily the case, the circular groove of FIG. 2 may be an advantage since one side of the tip is likely to be in contact with the inner wall of the ventricle. Of course, additional grooves can be added or the groove can be made spiral to suit manufacturing and other design convenience.

As mentioned above, one of the features of this electrode design is that its basic support is a near-noble metal which is perfectly adequate as a pacer electrode and which can function by itself in the same manner as previous electrodes should the platinum-black surface become seriously obstructed.

The electrical performance of the platinum-black electrode is assumed to be due to the rather special nature of platinum in that it is readily capable of absorbing atomic hydrogen and freely trading across its surface atomic hydrogen for hydrogen ions. The production of platinum-black greatly increases the effective platinum surface. The combination of these two effects is believed to account for the ability of the platinum-black to be the principal current carrier in spite of the adjacent large area of the titanium tip.

From the foregoing description it will be seen that this invention provides an advantageous muscle stimulator electrode construction which is easy to manufacture and capable of being of acceptable medical configuration. It is essentially non-polarizable by virtue of the extremely low resistance offered by the platinum surface, and further features a second electrode housing which is itself capable of carrying the stimulating current should there be any malfunction of the platinum.

Having thus described my invention and described in detail the preferred embodiments thereof, I claim and desire to secure by Letters Patent:

1. A muscle stimulator electrode comprising,
- a housing composed of a chemically inert conductor having a portion adapted to make electrical contact with the stimulation site, and
- a platinum surface within said portion.

2. An electrode as defined in claim **1** wherein said platinum is provided with a surface of platinum black.

3. An electrode as defined by claim **1** in which the projected surface area of the platinum is smaller than the surface area of the chemically inert portion of the housing.

4. A muscle stimulator electrode comprising,
- a housing composed of a chemically inert conductor having a portion adapted to make electrical contact with the stimulation site, and
- a surface of a non-polarizable electrode material within said portion.

5. An electrode as defined by claim **4** in which the projected surface area of the non-polarizable material is smaller than the surface area of the housing.

6. An electrode as defined by claim **1** wherein the housing is titanium.

7. An electrode as defined by claim **4** wherein the housing is titanium.

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