DESCRIPTION

The present invention relates to implantable electrodes for conveying electrical energy to a body part. More particularly, the invention is directed to endocardial electrodes for electrically connecting a pacemaker and a heart muscle.

Patent CH 570 804 discloses an electrode of this kind having a head of star-shaped cross-section to provide the head with recesses in which the heart tissue may grow to ensure, once the electrode has been implanted, proper fixation of the latter to the heart muscle. In this patent specification, the head of the electrode is moreover so designed that the current density in the conductive portions in contact with the heart tissue should be as high as possible. To this end, the surfaces of the recesses provided on the head are coated with insulating material over the major part of their area to reduce the contacting area and hence increase current density, the energy being transmitted by a large number of small conductive elements.

Patent FR 2 345 167 also discloses a heart pacing electrode comprising a head consisting firstly of a carbon tip for reducing the threshold at which a heart beat may be triggered and secondly of a cylindrical member separated from the carbon tip by insulating material and made of a material to which heart tissue may readily adhere. The cylindrical member may be made of a porous material or consist of several annular elements separated by spacers of lesser diameter to form annular recesses into which the tissue may grow to improve the fixation action.

However, none of the electrodes proposed in the above two patents provides a truly satisfactory answer. As to the Swiss patent it has been found that the efficiency of the transfer of energy to the heart muscle could be greatly improved not by increasing current density but, on the contrary, by increasing the area of electrical contact, i.e. by reducing contact resistance at the electrode-tissue interface. Moreover, the fact that, in this patent, the electrode is provided with axial grooves does not help the fixation action much since the repulsing action of the tissue acts mainly axially on the conductor and the electrode head.

One can note, in another respect, as to the above-mentioned French patent that the fact of having an electrode head made up of a plurality of separate elements, such as a carbon tip and a succession of annular elements, involves a more complex manufacturing process. The resulting electrode therefore tends to be rather costly.

The aim of the invention is to provide an implantable electrode which combines a good adherence to the tissue of the body part and a very low electrical resistance, and which is easy to make so that the manufacturing cost is low.

Patent EP-A-0 126 981 discloses a low-polarization low-threshold electrode the distal end of which is provided with two circular V-shaped grooves coaxially arranged on the head of the electrode. These grooves are intended to assist in fixation of the electrode to the endocardium by providing invaginations into which the tissue may grow, thereby avoiding displacement of the electrode from the endocardium and maintaining the triggering threshold at an acceptable value.

The object of the invention is thus to provide an implantable electrode, particularly an endocardial electrode, intended to establish a connexion with a body part, comprising an insulated conductor at the distal end of which is provided a conducting head intended to fasten onto an aimed tissue in order to make said connexion, the outer surface of the head being symmetrical about the longitudinal axis of the isolated conductor, characterized in that said outer surface is provided with a network of intersecting grooves integrally formed in the bulk of the head.

This feature provides the electrode with a relatively large area of contact, i.e. has a low impedance where it comes into contact with the tissue, while the intersecting grooves define a corresponding number of recesses in which the tissue may adhere to form with the head an intermeshing waffle-like arrangement that retains the electrode in place both axially and angularly.

According to another feature of the invention, it could be advantageous in order to increase the fixation action still further, to make the intersecting grooves with trapezoidal cross-section with flaring sides.

The head may have a variety of shapes, e.g. spherical, cylindrical, frustoconical, bifrustoconical or similar.

Preferably, the grooves intersect at right angles but may include a helical groove wound around the axis of the head and intersecting a plurality of longitudinal grooves distributed about the head.

The invention will be better understood with the following description, referring to the attached drawings, given by way of example and in which :

- Figure 1 is a partial view in axial section of an implantable electrode according to the invention;
- Figure 2 is a cross-section, on an enlarged scale, along line II-II of Figure 1;
- Figure 3 is a partial view in axial section of another implantable electrode according to the invention; and
- Figures 4 to 7 illustrate several constructional forms for the head of the electrode and its network of intersecting grooves.

The implantable electrode shown in Figures 1 and 2 is connected to a conductor 1 consisting in known manner of a hollow helicoidal winding of several strands of thin electrically conductive wire, the strands being also helicoidally wound. Conductor 1 is intended to be connected to an apparatus for supplying electrical energy to a part of the body. For instance, if the electrode is of the endocardial kind it may be connected to an implanted pacemaker or, when used in a hospital environment for instance, to an external pacemaker unit. The actual connection with the apparatus is done by means of a plug (not schown) fitted to conductor 1. It is to be noted that the "transmission" of the energy could be made in both directions, as the organ connected to the electrode may emit energy as well as receive energy, as for instance is the case for the so-called demand pacemakers.

Conductor 1 is provided with an insulating sheath 2 over its entire length.

The electrode comprises a head 3 made in a generally cylindrical member coaxial with the axis of conductor 1.

The rear portion of head 3, close to the conductor, is formed with an axial recessed hole 4 into which is inserted the end portion

of the conductor. The latter may be force fitted to head, 3, connected thereto by laser welding or it may be secured therein as by crimping head 3. A stopper 5 may close off conductor 1. Adjacent its rear end, head 3 is formed with an increased diameter portion 6, defining an annular shoulder 7, over which is slipped sheath 2 of conductor 1. The end portion of the sheath exhibits a portion 8 having a reduced diameter.

At the front end of head 3, there is also provided a recessed hole 9 which extends axially through head 10 and into head 3. This end is provided with a peripherical portion 10 which has a diameter larger than most of the member. The outwardly surface 11 of this peripherical portion 10 is a spherical one, while the face 12 of the head has a radial flat surface with respect to the axis of the head 3.

According to the invention, peripherical portion 10 is provided with intersecting grooves 13a and 13b, grooves 13a extending longitudinally of the head's axis and grooves 13b extending annularly around the head's axis in spaced apart relationship.

Grooves 13a and 13b each have a trapezoidal cross-section and flared sides.

This arrangement provides the head of the electrode both with a very extensive contact area and with a multitude of recesses with which the heart tissue may grow and adhere. Once such growth has occurred, the electrode is restrained from moving in all directions, particularly axially. For instance, when surface 11 has a maximum diameter of 2 mm, the middle annular groove has a depth of about 0.3 mm and the planes of its flared surfaces meet each other at an angle of about 40°.

Two lateral holes 14 are provided near the bottom of recessed hole 9. These holes are intended for the injecting of a plastic material in order to form an insulating sleeve 15 which goes from sheath 2 to peripherical portion 10. During the injection operation, the plastic material is filled through hole 9, i.e. from the front end of the head 10.

Sleeve 15 may have barbs 16, known per se, extending obliquely towards the rear to imprive adherence still further.

In the embodiment of Figures 1 and 2, the plastic material of sleeve 15 entirely fills hole 9. But, at shown in Figure 3, it can be different. Indeed, in this Figure, hole 9 is partly filled with a metallic stud 17, the front spherical surface of which merges with surface 11, in the same way as it is done with the plastic material in Figure 1.

It can be seen that grooves 13a and 13b may be produced by simple machining operations as with a lathe or a slotting cutter, thereby reducing the cost price. These operations enable the grooves to be provided with a bottom having a certain width of up to say 0.1 mm, such that the heart tissue may reach the bottom of each groove. However, the head may be also produced by known direct metal pressing methods.

As to materials, head 3 may be made of platinum or any other readily machinable electrically conductive metal that will permit the heart tissue to grow and adhere properly, whereas sheath 2 and sleeve 15 may for example be made of "Silastic" (trademark).

Grooves 13a and 13b may intersect at right angles or obliquely without affecting to any great extent the effectiveness of the electrode. Moreover, the peripheral portion 10 may have various shapes, e.g. a cylindrical shape 10A as shown in Figure 4, a frustoconical shape 10B broadening rearwardly, as shown in Figure 5, a bifrustoconical shape 10C as shown in Figure 6, and another cylindrical shape 10D as shown in Figure 7 in which the grooves network involves a single circumferential groove 18 extending helically.

CLAIMS

1. Implantable electrode, particularly endocardial electrode intended to establish a connexion with a body part, comprising an insulated conductor (1, 2) at one end of which is provided a conducting head (3) intended to fasten onto an aimed tissue in order to make said connexion, the outer surface (11) of the head (3) being symmetrical about the longitudinal axis of the isolated conductor, characterized in that said outer surface is provided with a network of intersecting grooves (13a, 13b, 18) integrally formed in the bulk of the head.

2. Electrode according to claim 1, characterized in that each of the intersecting grooves (13a, 13b, 18) has a trapezoidal cross-section, of which the lateral walls flare outwardly.

3. Electrode according to any one of claims 1 and 2, characterized in that the grooves when considered developped on a plan interesect at right angles.

4. Electrode according to any one of claims 1 and 2, characterized in that the grooves network comprises a continuous, helical groove (18) wound around the axis of the head (3).

5. Electrode according to any one of the preceding claims, characterized in that said outer surface (11) is of frustospherical or cylindrical or frustoconical or bifrustoconical shape.

6. Electrode according to any one of claims 1 to 5 comprising an outer insulating sleeve (15) which connects with the insulating part of the insulated conductor (1, 2), characterized in that the front end of said head (3) is provided with a recessed hole (9) extending axially through this head and communicating with the outer side through at least one lateral hole (14) which allows the plastic material intended to form the sleeve to pass, when realizing said sleeve (15) by injection.

* C L M S *