United States Patent [19]

Berkovits

[11] **3,729,008**

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[54] **ELECTRODE FOR ATRIAL PACING WITH CURVED END FOR ATRIAL WALL ENGAGEMENT**

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[73] Assignee: **American Optical Corporation,** Southbridge, Mass.

[22] Filed: **Dec. 28, 1970**

[21] Appl. No.: **101,836**

[52] **U.S. Cl.** .....**128/418,** 128/348, 128/419 P

[51] **Int. Cl.** **A61n**

[58] **Field of Search** .....128/348, 349 R, 350 R, 128/404, 418, 419 P, 2 M

[56] **References Cited**

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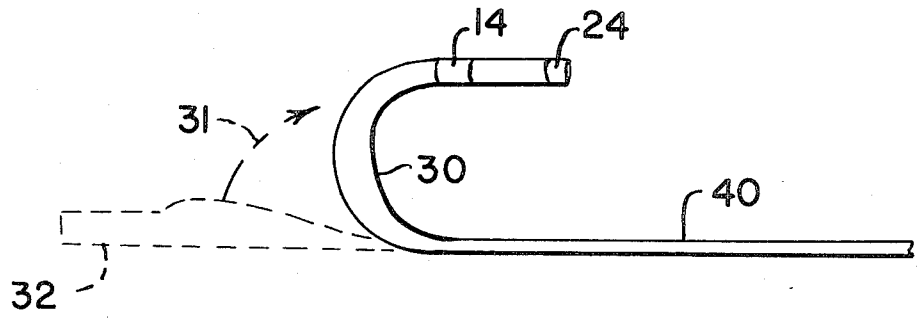
[57] **ABSTRACT**

A curvilinear electrode suitable for being curved-over and supported by a moving atrium wall of a patient's heart. The electrode includes at least one long, thin, flexible electrical conductor encapsulated by an electrically insulating flexible catheter sleeve. The electrode has a sufficient resilience to maintain the curve in a plane and yet allow the curve to be flexed linear for insertion through a blood vessel of the patient.

9 Claims, 6 Drawing Figures



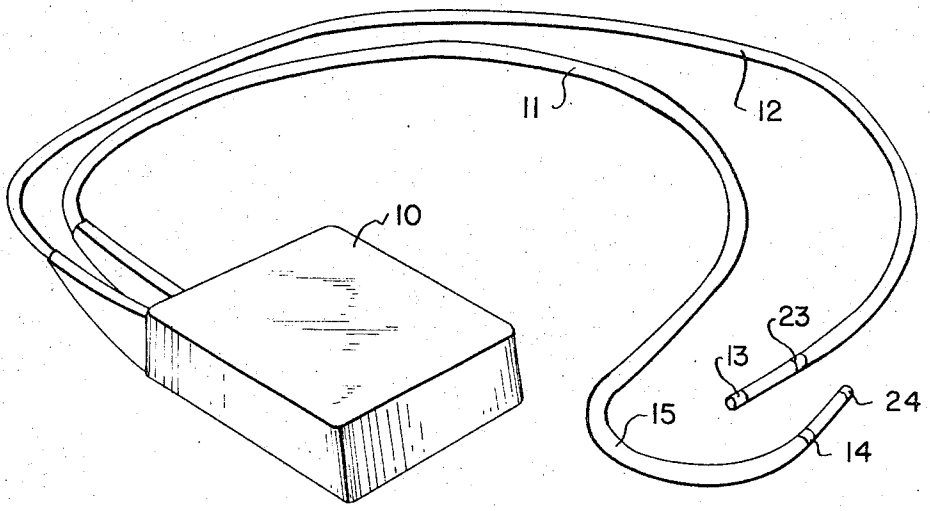


FIG. 1

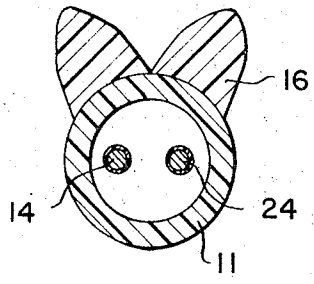


FIG. 2

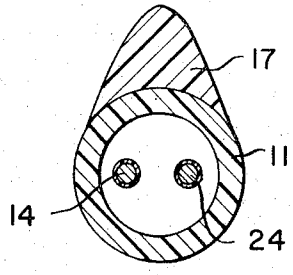


FIG. 3

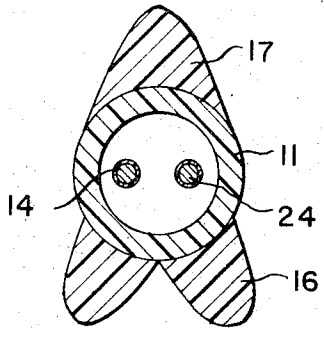


FIG. 4

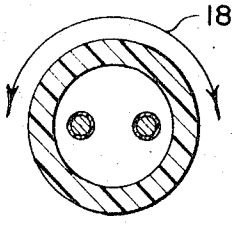


FIG. 5

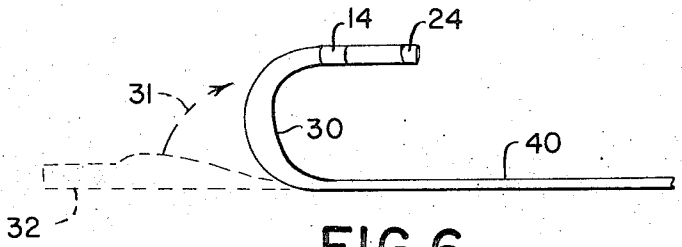


FIG. 6

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ELECTRODE FOR ATRIAL PACING WITH CURVED END FOR ATRIAL WALL ENGAGEMENT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates, generally, to an area of medical electronics concerned with electrical stimulation of a patient's heart. More particularly, the present invention relates to improved means for conducting electrical stimulation from heart stimulating apparatus to the atrium of the heart.

2. Description of Prior Art

In the medical electronics field, electronic devices have been developed for providing stimulation to the heart. These electronic devices are commonly called pacers. An example of a demand pacer is disclosed in U.S. Pat. No. 3,528,428 issued in the name of the applicant of the present invention.

Applicant has filed other pacer patent applications including Ser. No. 810,519 filed on Mar. 26, 1969 and which has matured into U.S. Pat. No. 3,595,242, and 884,825 filed on Dec. 15, 1969 and which has matured into U.S. Pat. No. 3,661,158. In these copending applications, heart stimulating devices are disclosed that stimulate both an atrium and a ventricle of the heart. These pacers require two sets of electrodes. The present invention is capable of use with most pacers and is particularly adapted for use with this latter type of pacer.

The electrodes normally used with these devices are long, thin, flexible conductors enclosed by a flexible catheter. At one end of the catheter, the conductor is exposed in order to make contact with the heart.

In some electrode apparatus configurations (called bipolar electrodes), two conductors are included within one catheter, thereby providing a forward conduction path and return path for electrical stimulation to the heart. For this type of electrode, two conductors are exposed and each conductor makes contact with the heart.

The bipolar electrode apparatus used with ventricular stimulation has a generally linear and flexible shape. The two conductors are exposed at one end of the catheter approximately 1 inch from each other. The electrode apparatus is inserted into a blood vessel and is pushed into the ventricle. It normally rests in the ventricular cavity without falling out. The ventricle is formed so that the electrode will normally be confined to its region without difficulty.

But, by comparison, the electrode used for stimulating an atrium has difficulty in maintaining its position within the confines of the atrial cavity. The atrium has smooth walls allowing easy slippage of an ordinary linear electrode therefrom.

Thus, a problem with the prior art electrode is that it is not well suited for use with the atrium. Applicant's solution to this problem is to provide improved electrode apparatus which can be inserted in a normal manner into a vessel of the body leading to the atrium, and to automatically cause a gripping of, and a support by, the atrium wall. The present invention solves the electrode-heart contact problem associated with atrial pacing.

SUMMARY OF THE INVENTION

The invention relates generally to electrode apparatus for use with heart stimulating devices. More particularly, the invention relates to a curved electrode apparatus and catheter particularly suited for use in stimulating an atrium of a patient's heart. A particular resilience is built into the catheter to provide a particular shape suitable for being supported by the wall of the atrium. The resilience built into the catheter has a twofold purpose; first it can create an axial torque to cause a twisting action to tend to maintain the curve in a plane, and second it has a flexibility for providing an approximately linear shape for proper insertion into a blood vessel.

An advantage of this invention is to permit reliable atrial stimulation. The electrode of the present invention will not slip out of the atrium, nor will it loosen and make poor electrical contact with the atrium.

It is thus an object of the present invention to provide an improved electrode apparatus for use with heart stimulating devices.

It is a further object of the present invention to provide an improved electrode for stimulating an atrium of the heart.

Other objects and advantages of the present invention will become apparent to one having reasonable skill in the art after referring to the detailed description of the appended drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts two electrodes, one of which is curvilinear in accordance with the present invention, both of which are operatively connected to a heart stimulating device;

FIG. **2** is a sectional view of the catheter **11** of FIG. **1** in a first illustrative embodiment of the present invention;

FIG. **3** is a sectional view of a second illustrative embodiment of the present invention;

FIG. **4** is a sectional view of a third illustrative embodiment of the present invention;

FIG. **5** depicts schematically the axial or twisting torque provided by the present invention; and,

FIG. **6** is a side view of a curved electrode in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, heart stimulating device **10** is connected to catheter **12** which encloses conductors **13** and **23**. These conductors are insulated from each other. One provides a signal or stimulating conductive path and the other provides a return conductive path. This catheter electrode apparatus is an example of prior art. It is inserted into the ventricle of the heart to provide it with electrical stimulation.

By comparison, catheter **11** is also operatively connected to pacer or heart stimulator **10**, and similarly has conductors **14** and **24** enclosed therein. But, this catheter is curvilinear or curved near the end that makes contact with the heart. The cross-section of catheter **11** at the location designated as **15** is thicker than the cross-section of the catheter at a point closer to the pacer. This can be seen more clearly in FIG. **6**.

In FIG. 6, curved region designated as 30 is thicker in cross-section than the catheter cross-section at the location designated as 40. The reason for this difference in cross-section is due to an additional amount of resilient insulation at region 30.

The catheter can be made from various electrical non-conductive materials such as polyvinyl chloride, plastics, polyethylene, polyurethane and other body-compatible elastic materials. In the present invention, the catheter is made from a high medical grade durameter (resilient) rubber. The additional amount of rubber at the location of the curve is added to the ordinary flexible catheter by such processes as vulcanization or injection molding. The additional rubber forces the catheter to assume an unnatural shape but one which possesses minimal potential energy.

In FIG. 6, the catheter is depicted as temporarily linear, and this is shown by dotted diagram 32. This is the shape and potential energy state of the catheter when it is inserted into a blood vessel (not shown) to be pushed up to the atrium (not shown).

Upon entering the atrium, the catheter springs back as depicted by direction 31 to the curve shape depicted. This curve shape has the proper dimensions to conform to the atrium and to be suitable for gripping the moving atrium wall. The atrium has a smooth wall which allows easy slippage of an ordinary electrode. The curved electrode shown in FIG. 1 and FIG. 6, will now slip from the atrium, as it is curved over the atrium wall. While inserted in the heart over the atrium wall (not shown), the inherent return tension or resilience causes the catheter to apply tension in step with the moving atrium as the heart is beating. This maintains good electrical contact.

The curved electrode fits into the atrium and will not fall out and slide into the ventricle (not shown) by virtue of its shape. But, the electrode can be pulled out by application of distal force in a surgical procedure. When the electrode is removed from the atrium by the application of distal force, the shape of the curved catheter is shown by dotted configuration 32.

FIG. 2 is a cross-section of the curved electrode taken at curved region 15 of catheter 11. Flanges 16 are what cause the electrode to maintain its curved shape. Flanges 16 lie on the inside of the curve. (They could be on the outside of the curve and the resulting resilience effects would be similar.)

FIG. 3 is a second illustrative embodiment of the present invention taken at curved region 15 of catheter 11. Flange 17 is shown in a different shape from flanges 16, but has much the same effect as flanges 16.

FIG. 4 is a third illustrative embodiment of the present invention taken at curved region 15 of catheter 11 and is a combination of flanges 16 and 17. In FIG. 4, flange 17 is at the inside of the curve and flanges 16 are on the outside of the curve. This configuration combines the resilient advantages of FIGS. 2 and 3.

The purpose of the flanges is two-fold. First, a resilient restoring force must be created to make the electrode spring back in direction 31 as depicted in FIG. 6. Second, the flange is intended to diminish twisting (axial torques which will tend to displace the curve portion of the electrode out of a plane) and thus encourages the curve portion to be planar. (If a curved electrode is allowed to twist excessively while in operational connection with an atrium, it could fall out of the atrium cavity.)

In FIG. 5, arrows 18 indicate directions in which the axial torque resisting force is applied by flanges 16 and 17. In FIG. 6, application of this torque resisting force will tend to cause the curve of the electrode to remain in the plane of the paper.

In a preferred embodiment, the curve has a 1-inch radius, and is generally in the shape of a semi-circle. There is approximately 1.5 to 2 centimeters between exposed conductors of the same catheter. The exposed conductors can be made of platinum.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Other cross-sectional areas of rubber, or other materials suitable for creating these torques within a body environment can be used. Also, grooves or ridges can be arranged on the inside curve of the catheter to even better grip the atrium wall.

The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within immediate range of the claims, are therefore intended to be embraced therein.

What is claimed is:

1. Electrode apparatus of the intravascular type for use with devices for electrically stimulating the heart of a patient, said apparatus including at least one long, thin, flexible electrical conductor, an electrically-insulating flexible catheter enclosing said conductor, there being an electrically non-conducting material forming an outer wall of said catheter, said conductor having one end extending through the exterior surface of said catheter to permit electrical contact between said heart and said conductor near one end of said conductor, and catheter curve-holding means carried by said outer wall adjacent said end and substantially parallel to and secured along substantially its entire length to the catheter for normally urging said catheter in a curve near said end, the configuration of said curve arranged to be curved-over and supported by a wall of an atrium moving in response to the beating of said heart and being suitable for causing electrical contact to be maintained between said conductor and said atrium, and where said catheter curve-holding means further includes torsion means for maintaining an axial restoring torque on said catheter at said end to encourage said curve to be planar.

2. Electrode apparatus as recited in claim 1 and wherein said catheter curve-holding means further includes flexible means for permitting said curve to be extended into an approximately linear shape for insertion of said catheter into and removal of said catheter from a blood vessel leading to the heart of said patient.

3. Electrode apparatus as recited in claim 2 and wherein said catheter curve-holding means further includes contractile means for causing said approximately linear shape to be formed into said curve about the top of said wall of said atrium after said insertion into said heart.

4. Electrode apparatus as recited in claim 1 and wherein said catheter curve-holding means is made of rubber.

5. Electrode apparatus as recited in claim 1 and wherein said apparatus includes two conductors.

6. Electrode apparatus as recited in claim 1 and wherein said catheter curve-holding means includes ridges for increased gripping of the atrium wall.

7. Electrode apparatus as recited in claim 1 and wherein said catheter curve-holding means is made of polyvinyl chloride.

8. Electrode apparatus as recited in claim 1 and wherein said catheter curve-holding means is made of polyethylene.

9. Electrode apparatus as recited in claim 1 and wherein said catheter curve-holding means is made of polyurethane.

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