

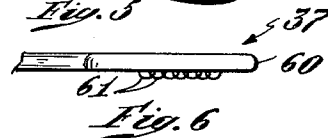
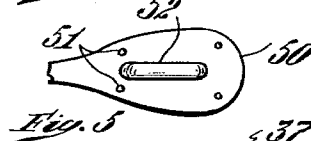
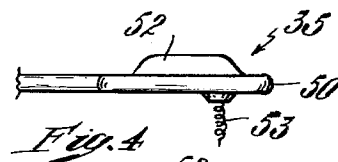
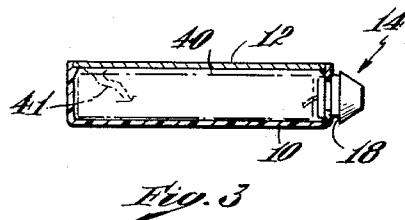
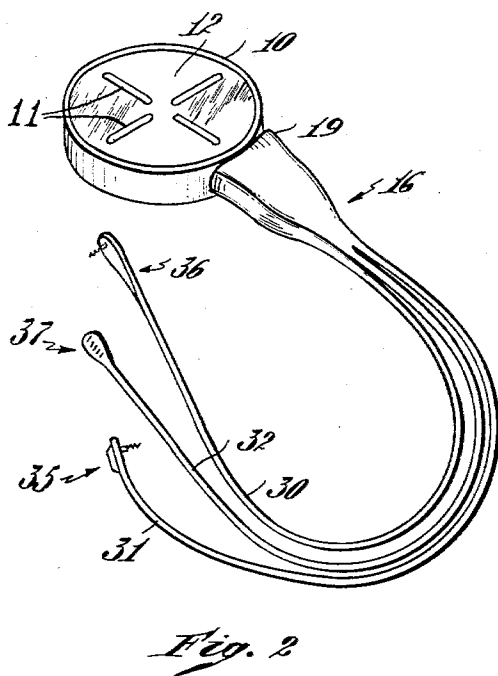
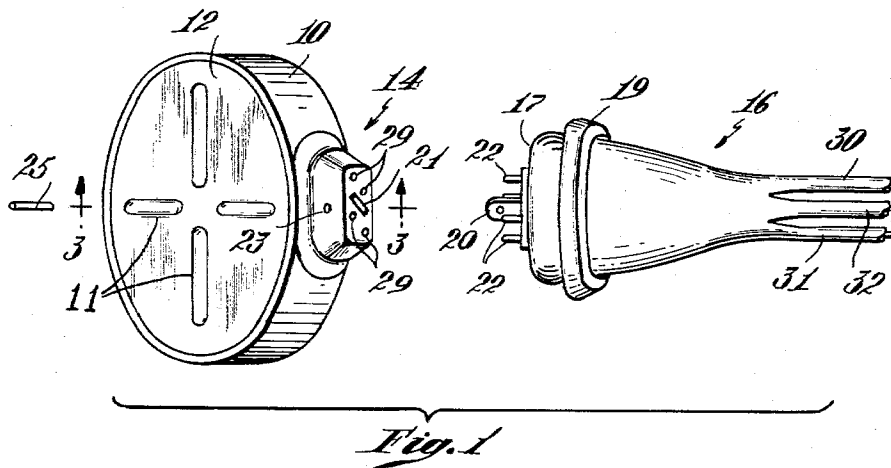
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CARDIAC PACER ELECTRODE SYSTEM

Filed Aug. 7, 1963



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CARDIAC PACER ELECTRODE SYSTEM

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This invention relates to implantable cardiac pacers and more particularly to an electrode system for use with such pacers.

Heretofore it has been conventional practice in the use of implantable pacers to apply ventricular stimulation to a patient's heart between two electrodes both of which are placed in spaced relation on the heart itself. Sensing of the P-wave at the heart for various electrocardiac functions has been accomplished in very similar manner.

According to the present invention it has been found that satisfactory and even superior stimulation of the ventricles can be achieved when one electrode is placed on the heart in conventional fashion and another electrode, of relatively large surface area, is placed in contact with tissue in a place remote from the heart, usually the abdomen. The ground electrode remote from the heart is large in area in order to reduce the current density and prevent local stimulation of muscle tissue. Conversely, the stimulating electrodes inserted in the heart muscle are small in area in order to increase their current density and cause stimulation at that point. The use of a remote "ground" is further useful in that it permits a simplification of leads or, if a plurality of stimulation electrodes are implanted as is current practice, it permits a choice of stimulation contact points at a time after the original implantation without further surgery in the region of the heart itself.

The remote electrode according to the present invention has particular utility in synchronous cardiac pacers such as that shown in copending application Serial No. 283,271, filed May 27, 1963 and entitled Cardiac Pacer. In that synchronous pacer, stimulation to the ventricles is applied after a suitable delay following the contraction of the atrium as indicated by the presence of the so-called P-wave. The spread of the P-wave signal over the surface of the atrium is in the form of a circumferential voltage gradient emanating from the sino-auricular node and passing over the atrium relatively uniformly. However, as the exact location of the sino-auricular node is not easily determined in practice, it is possible that if two sensing electrodes placed on the heart are used they will be equidistant from the node and will experience no or very little potential difference. The P-wave may, however, be advantageously detected between an electrode placed adjacent the atrium and the large remote electrode according to the present invention. The specific advantage of a remote ground is that it offers a relative level of potential unaffected by the point of origin of the P-wave and therefore provides extremely reliable sensing of the P-wave.

Preferably the large, common electrode is incorporated into the housing for the pacer circuitry and the entire pacer is located relatively remotely from the heart with appropriate leads extending to the electrodes placed at the heart. By incorporating the remote electrode into the pacer circuit housing the same conductive surface which serves as a large area of contact with abdominal tissue can also be employed as an electric and magnetic shield for the pacer circuitry so that that circuitry will be so affected or triggered by extraneous fields.

In a preferred embodiment of the invention two stimulation electrodes and their associated leads are connected to the pacer circuitry through a reversible plug

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and jack connection so that, merely by reversing the plug, a choice may be made as to which stimulation electrode is operative.

For the purpose of illustration a preferred embodiment of the invention is shown in the accompanying drawing in which

FIG. 1 is a perspective view of a cardiac pacer and its cooperating lead assembly in disassembled relation;

FIG. 2 is a perspective view of the pacer and lead assembly of FIG. 1 in assembled relationship;

FIG. 3 is a section substantially on the line 3-3 of FIG. 1;

FIG. 4 is a side view of a stimulation electrode;

FIG. 5 is a top view of the stimulation electrode;

FIG. 6 is a side view of a sensing electrode.

Referring now to the drawing, the pacer circuitry 40 with its powering batteries is contained within a disc-shaped plastic case 10 having an inserted metal cover 12. The cover may be ribbed as at 11 to provide stiffness. At one side of the case 10 there is provided a four terminal jack 14 by means of which a lead assembly 16 may be connected to the pacer circuitry. In the embodiment shown the jack 14 has an annular recess 18 and the lead assembly plug 17 includes a corresponding mating boot or lip 19 constructed of a resilient material such as silicone rubber so that the connections may be sealed and protected from the entrance of corrosive body fluids. In FIG. 1 this lip is shown rolled back so as to facilitate the insertion of the plug 17 into the jack 14.

To further provide a locking engagement between the plug 17 and the jack 14 the plug includes an apertured tab 20 fitting within a corresponding opening 21 in the jack 14. A transverse bore 23 allows a pin 25 to be inserted through the jack 14 and the apertured tab 20 thereby locking the plug and jack together. To facilitate this pinning the lip 19 may be rolled back on the plug 17 as shown in FIG. 1.

In the preferred embodiment shown the plug pins 22 and the corresponding receptacles 29 in the jack 14 are arranged in a symmetrical pattern so that the plug 17 may be inserted in either of two positions which are obtained by rotating the plug through 180°. Three leads 30, 31 and 32 emanate from the plug 17. Two of these leads 30 and 31 terminate in pronged stimulation electrodes 35 and 36 suitable for implantation on the ventricular portion of a heart. The stimulation electrodes (FIGS. 4 and 5) include flat tabs 50 of silicone rubber having apertures 51 by means of which the electrode can be sutured to the heart. A rib 52 on the back of the tab 50 facilitates its manipulation during surgery. The actual contact surface is in the form of a projecting coil 53 of platinum wire which can be inserted into a puncture wound made in a patient's heart. The spacing between adjacent turns of the coil is approximately .010 to .025 inch so that the heart tissue can grow back between the turns without the formation of such scar tissue as would increase the contact resistance. The contact surface is, however, kept localized so that the stimulation pulse current density is high enough to produce satisfactory cardiac stimulation.

The third lead 32 from the plug terminates in a sensing electrode 37 appropriate for sensing the P-waves adjacent the atrial portion of the heart. The sensing electrode (FIG. 6) also employs a flat apertured tab 60 but, since contact resistance is not of as great significance in this application, the contact surface is in the form of shallow loops 61 of platinum wire which project from the bottom of the tab. In the preferred embodiment of the invention the electrodes are connected to the jack 17 so that one of the stimulating electrodes 35 and 36 is connected to each of the outer ones of the plug pins 22 and the

sensing electrode 37 is connected to both of the inner pins. The length of the leads 30, 31 and 32 is such that, with the electrodes 35, 36 and 37 placed on a patient's heart, the pacing circuitry case 10 may be placed in the patient's abdomen.

The pacer circuitry, indicated generally as 40 in FIG. 3, is connected, as at 41, so as to employ the metal cover 12 as a common electrode for establishing a reference potential. The P-wave is then reliably sensed between the electrode 37 and the plate 12 while stimulation pulses are applied to the heart between one of the electrodes 35 and 36 and the metal cover 12. In the embodiment shown the metal cover 12 provides a contact surface with the adjacent tissue of approximately 3.1 sq. in., an area sufficiently large to prevent local muscle stimulation during the application of the stimulating pulse. The metal cover 12 also, because of its substantial extent and adjacent relation to the pacer circuitry 40, provides effective shielding of the circuit against the effect of external fields. If desired, more complete shielding may of course be obtained by constructing the entire housing of metal so that the circuit is completely enclosed by a conductive surface.

The use of a remote "ground" facilitates such a sensitive detection of the P-wave that it is possible to sense this wave by means of an electrode which is in fact placed on the ventricular portion of the heart. Accordingly, since the stimulation function follows in time the sensing of the P-wave, it is possible according to the invention to provide synchronous cardiac pacing using but one electrode placed on the heart if suitable precautions are taken to prevent interaction between the input and output circuits which then share both the electrode at the heart and the remote "ground."

In the preferred embodiment shown the pacer circuitry within the case 10 is connected to the jack 14 so that the input circuit is connected to the two inner jack receptacles 29 while the stimulation pulse output circuit is connected to only one of the outer of the receptacles 29. In this way a choice may be made as to which of the stimulation electrodes 35 and 36 will be employed for stimulation merely by appropriately positioning the plug 17. The other of the stimulation electrodes may be held as a spare and, if necessary, may be placed into operation merely by reversing the plug 17 in the jack 14, this connection being relatively easily accessible at the abdomen as opposed to the difficulties encountered in re-implanting stimulation electrodes on the heart. Having such a spare is highly desirable in case one of the electrodes develops too high a threshold for effective stimulation.

While a particular embodiment has been disclosed by way of illustration, it should be understood that the present invention includes all modifications and equivalents falling within the scope of the appended claims.

We claim:

1. An electrical cardiac pacer for implantation entirely within a body, comprising a housing enclosing a circuit for producing cardiac stimulation signals, a first electrode for application to a location on the heart within said body, a second electrode providing a return path from said body to said circuit, and connections between said electrodes and said circuit, characterized in that said second electrode is of substantially larger surface area than said first electrode, in that the connection between said circuit and said first electrode is longer than the connection between the circuit and said second electrode and extends in a different direction whereby the second electrode may be located outside the region of the heart, and in that said housing includes a conductive wall member comprising said second electrode.
2. A cardiac pacer according to claim 1 further characterized in that said wall member is disposed closely adjacent said circuit to shield said circuit from electromagnetic fields.
3. A cardiac pacer according to claim 1 further characterized by a third electrode attached to a location on the heart different from the aforesaid location for sensing a cardiac signal appearing between said third and second electrodes, and a connection between said third electrode and circuit for controlling the production of heart stimulation signals by said circuit, said circuit having means responsive to the signal sensed by the third electrode for controlling signal production by the circuit.
4. A cardiac pacer according to claim 2 further characterized by a third electrode attached to a location on the heart different from the aforesaid location for sensing a cardiac signal appearing between said third and second electrodes, and a connection between said third electrode and circuit for controlling the production of heart stimulation signals by said circuit, said circuit having means responsive to the signal sensed by the third electrode for controlling signal production by the circuit.

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