United States Patent

Auphan

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[54] **HEART STIMULATOR AND HEART-POWERED ENERGY SUPPLY THEREFOR**

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

[51] **Int. Cl.**.....**A61n 1/36**

[58] **Field of Search**...128/1 R, 419 P, 419 R; 310/37

[56] **References Cited**

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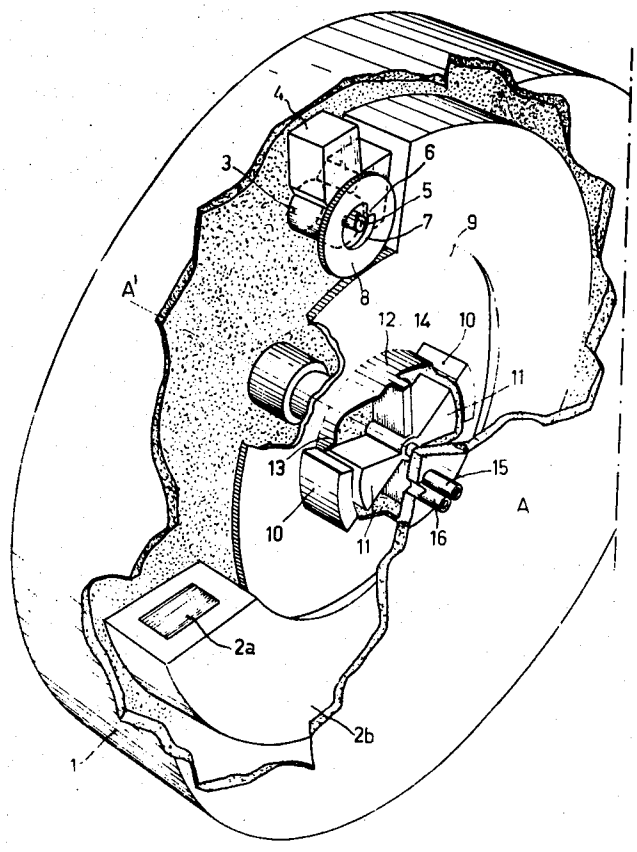
[57] **ABSTRACT**

A device for supplying electrical energy to a heart stimulator which is formed as an air-tight casing arranged to be placed within the human body in close proximity to the heart muscle. The casing has housed therein an annularly arranged magnetic circuit with a rotor arranged in a gap of the circuit. A rotary piston is accommodated within a piston chamber having four compartments divided in pairs. One of the pair is connected via a flexible tube to a first flexible bag arranged at the tip of the heart and the other pair communicates via another flexible hose to a second flexible elastic bag. The elastic bags contain fluid which communicate alternately between the pairs of compartments within the chamber so that upon the pumping action of the heart the piston is caused to oscillate in a rotary motion and mechanical coupling means are connected between the piston and a driving member mounted coaxially with the rotor so as to drive the rotor thereby producing electrical signals in response to the movement of the heart.

7 Claims, 4 Drawing Figures



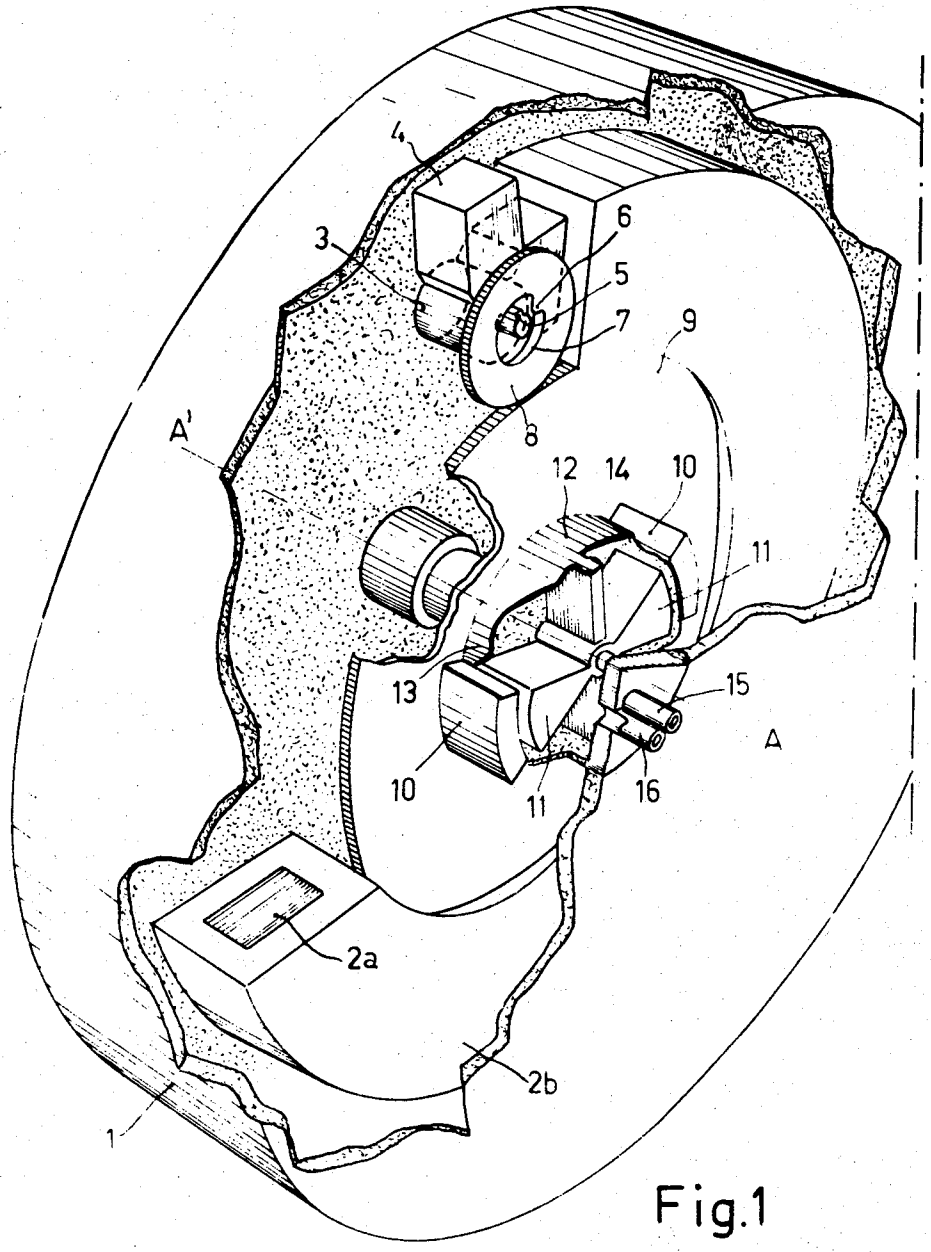


Fig.1

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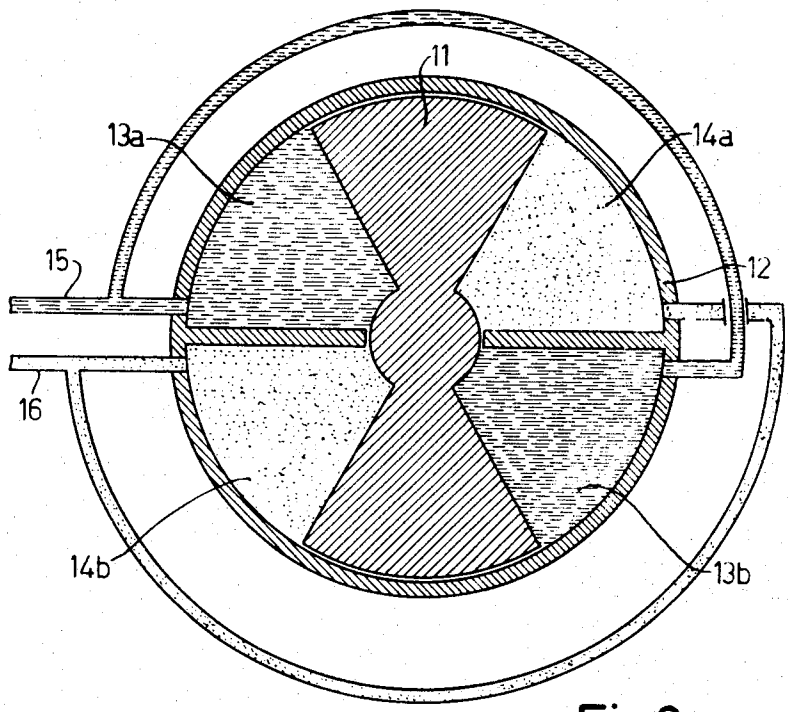


Fig.2

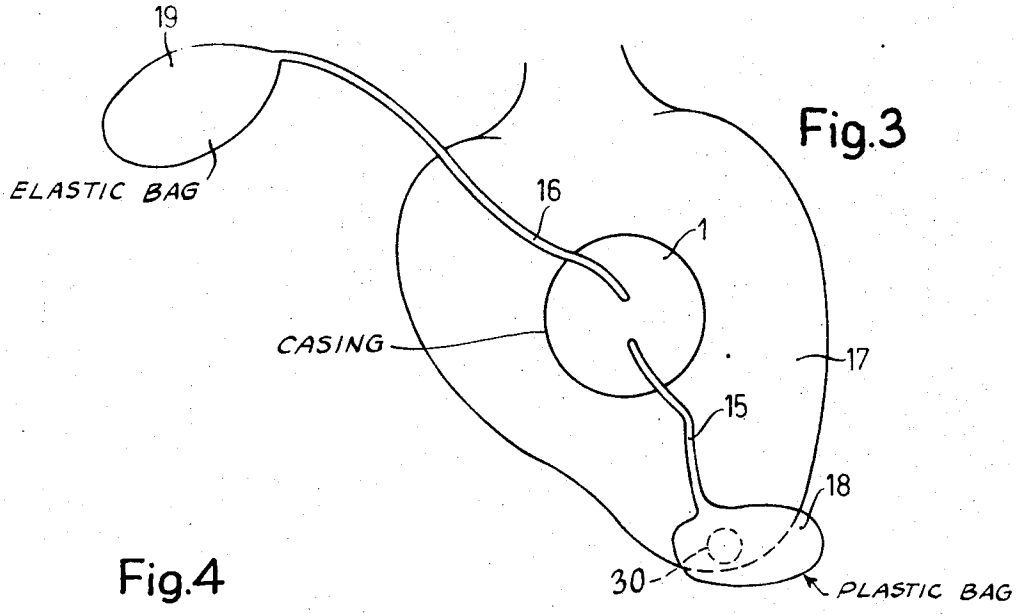
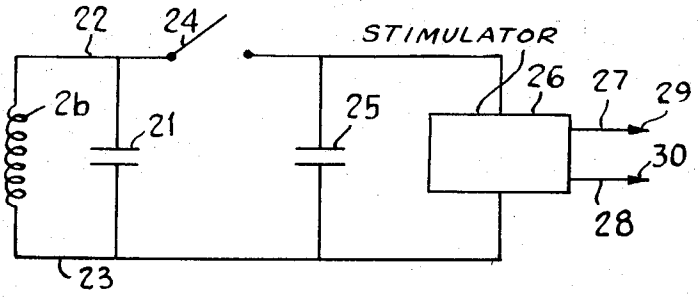


Fig.3

Fig.4



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HEART STIMULATOR AND HEART-POWERED ENERGY SUPPLY THEREFOR

This invention relates to a supply device for an intracorporal heart stimulator in the domain of medical prostheses.

Cardiac stimulators used for some diseases provide electric pulses to the myocardium by electrodes, different sources of energy are available for feeding these stimulators.

It is now common practice to use a battery within the body, but this involves two disadvantages: on the one hand the longevity of a battery is limited and on the other hand rupture of the flexible wires connecting the battery to the stimulator may occur due to shaking by the heart beat.

Research made on the sources of energy suitable for such uses tends to obviate these disadvantages by developing an autonomic source of energy, which will be substantially independent of time.

In this respect research has been made for developing batteries having electrodes consumable by biological liquids. However, the longevity of these electrodes and any toxic effects they may have on the organism cannot be guaranteed.

Also, the use of thermal sources taking their energy from nuclear reaction involves many problems relating to either the dangers of the circulation of a radioactive material or the heat exchange at high temperatures also the cost of an apparatus based on this principle would be prohibitive

The use of the mechanical energy of the heart proposed in various methods should lead to an interesting solution. In fact, since the heart gives off about 15 W in contracting it must be capable of supplying the few hundred microwatts required for feeding a stimulator.

However, the mecano-electric transformation tests on piezo-electric materials have not produced the desired results. Since the charges accumulated at each mechanical deformation of the piezo-electric bodies are low, these deformations have to be accumulated to the highest possible frequency for obtaining a sufficient total energy.

A different solution has been described by the Applicant in French Pat. No. 1,460,772 and the Patent of Addition Nr. **92 782**. The apparatus proposed forms not only an electric current generator but also a pulse generator for stimulating the heart. It comprises in an air-tight box a magnetic circuit, in the gap of which a rotor is adapted to oscillate between two pivots. An oscillation of the box produded by the movement of the heart causes the rotor to pass from an unstable position to a stable position and during this movement a sequence of rapid oscillations of the rotor induces in the magnetic circuit an oscillatory current of decreasing amplitude. For transmitting the movement of the heart the box comprises a pendulum associated with a rotatable piece coaxial to said rotor and provided with a contact finger which co-operates with a pin of said rotor. This system, however, can only provide pulses at a predetermined frequency usually of about 1 Hz. For many cases it is, however, desirable to have available a system of variable frequency so that the heart may obtain pulses at different rhythms.

The present invention based on the same principle of mecano-electric transformation provides a supply

device for an intracorporal heart stimulator, which may be of the conventional type.

The supply device is formed by a member converting mechanical energy into electric energy and comprises an oscillatory rotor arranged in the gap of a magnetic circuit and means for transmitting the movement of the heart to said rotor, which means comprise a rotatable piece coaxial to said rotor and provided with at least one mechanical contact member for driving said rotor.

According to the invention said means further comprises a rotatable piston mechanically coupled with the rotatable piece and a member controlling the displacements of said piston in accordance with the movements of the heart.

Various characteristics of the invention will be apparent from the following description given by way of example with reference to the accompanying drawings, which show

in FIG. **1** an elevation of the open casing comprising the supply device in accordance with the invention;

in FIG. **2** a schematic view of the rotatable piston shown at the center of FIG. **1**;

in FIG. **3** an over-all view of the casing and the transmission of the movements of the heart; and in FIG. **4** a schematic diagram showing the stimulator.

An airtight casing **1** accommodates an annular magnetic circuit **2*a*** associated with a winding **2*b***, the gap accommodating a rotor **3**. Two auxiliary magnets **4** of the kind described in the aforesaid Patent Specification produce a magnetic field at right angles to the axis of the rotor and hence a return-couple for the latter.

The rotor is provided with a driving pin **5** co-operating with a finger **6** of a rotatable piece **7** which is coaxial to the rotor, the pin **5** and the finger **6** forming the mechanical contact elements for driving said rotor. The rotatable piece is provided with a gear wheel **8** in mesh with the gear wheel **9** associated with a rotatable piston **11**, mounted along the axis AA' of the casing **1** inside the annular magnetic circuit. The space **12** accommodating the piston **11** is divided into four chambers **13*a***, **13*b***, **14*a*** and **14*b*** of pairwise equal, variable volumes. These chambers (see FIGS. **2** and **3**) are connected, as far as the first two are concerned by the flexible tube **15** with a plastic bag **18** arranged on the tip of the heart **17**, the two others, by the flexible tube **16** with an elastic bag **19** of expansion.

Initially the bag **18** is filled with a liquid. At each systole the bag **18** is compressed between the tip of the heart and the surrounding tissues; the liquid is thus expelled into the flexible tube **15**, it traverses the space **12** and emanates from the tube **16** towards the bag **19**. After the systole the tension of the second elastic bag pushes the liquid back to the first bag, which is no longer subjected to the pressure of the tip of the heart.

During each reciprocatory flow of the liquid, the rotatable piston **11** is caused to perform an alternating movement which is transmitted by the gear wheels and produces the oscillation of the rotor under the action of the couple produced by the magnets **4**.

The winding **2*b*** of the magnetic circuit **2*a*** is connected to the terminals of a first capacitor, so that an oscillatory circuit is formed. If the frequency of the latter lies near the oscillation frequency of the rotor, an automatic transmission of energy is obtained from the rotor to the oscillatory circuit.

Each time when the energy reaches its maximum level, it is transmitted, for example, by an electric switch **24**, to a second capacitor **25** for feeding a stimulator **26** of conventional type.

The switch **24**, the capacitor **25** and the stimulator **26** may be accommodated inside the casing **1** near the rotatable piston for instance. (not shown for the sake of clarity).

The pulses generated by the stimulator **26** are transmitted via leads **27** and **28** to electrodes schematically indicated by arrows **29** and **30**, one of these electrodes may be formed by the casing **1**, whereas the other (**30**, see FIG. **3**) may be fixed to the flexible bag **18**, when the liquid is conductive.

In order to ensure a perfect seal between the space **12** and the assembly of the device the driving system is formed by a magnetic coupling so that a shaft traversing the casing is not required.

For this purpose the piston **11** is made of magnetic material and associated with two external, symmetrical magnets.

The invention may be used in the treatment of given cardial diseases by prostheses.

What is claimed is:

1. A device for supplying energy for an intracorporal heart stimulator, comprising an airtight casing to be placed within the human body, an annularly arranged magnetic circuit housed within said casing, a winding coupled to said magnetic circuit to produce electrical energy said circuit having a gap therein, a rotor arranged in said gap for oscillatory movement, a multicompartment piston chamber arranged within said magnetic circuit, a piston mounted for rotatable movement within said chamber about an axis of rotation parallel and eccentric to the axis of rotation of said rotor, hydraulic means connected with said chamber for transmitting pulses thereto in response to movements of the heart so as to cause rotational displacement of said piston in accordance therewith, , a driving member rotatably mounted coaxially with said rotor and having means contacting said rotor for driving same, and mechanical coupling means for causing movement of said driving member in response to rotational movement of said piston so that when said piston is rotatably driven as a result of heart movement said driving member will be caused to rotate and cause oscillatory movement of said rotor so as to produce electrical energy.

2. The device according to claim **1** wherein said piston chamber comprises first, second, third and fourth compartments, the volume of said first and third compartments being variable and equal to each other, the volume of said second and fourth compartments being variable and equal to each other and wherein said hydraulic means comprises a first flexible bag arranged on the tip of the heart, a first flexible liquid circulation tube connected to said first flexible bag and communicating with said first and third compartments, a second elastic bag of expansion and a second flexible liquid circulation tube connected to said second elastic bag of expansion and communicating with said second and fourth compartments.

3. The device according to claim **1** further comprising at least one magnet disposed near said rotor for producing a magnetic field perpendicular to said rotor.

4. The device according to claim **1** wherein said piston is mounted for rotation about an axis of the casing which is filled with air, and wherein said piston is made of magnetic material and further comprising a pair of magnets arranged symmetrically outside of said piston chamber so as to form a magnetic coupling thereby producing a drive for the piston.

5. The device according to claim **1** further comprising a capacitor connected to said winding and forming an oscillatory circuit for the transmission of the mechanical energy of the rotor.

6. The device according to claim **1** wherein said mechanical coupling means for causing movement of said driving member in response to rotational movement of said piston comprises a first gear wheel arranged on said driving member and a second gear wheel associated with said piston and arranged in mesh with said first gear wheel.

7. The device according to claim **1** further comprising a heart stimulator carried within said casing, an energy accumulator connected to said stimulator and a switch for connecting said oscillatory circuit to said energy accumulator, one of the electrodes of said stimulator being formed by said casing and the other electrode being fixed to said flexible bag at the tip of the heart.

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