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[54] METHOD OF SYNCHRONIZATION AND STIMULATION BY MEANS OF PULSE PAIRS AT IMPLANTED HEART STIMULATORS WITH CONSTANT RHYTHM AND THE CIRCUIT FOR IMPLEMENTATION OF THIS METHOD

[72] Inventors: **Bohdan A. Bukowiecki**, ul. L. Staffa 12/14 M 23; **Mariusz Stopczyk**, ul. J. Dabrowskiegv 86 m 71, both of Warsaw, Poland

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

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

[58] **Field of Search** 128/419–423

[56] **References Cited**

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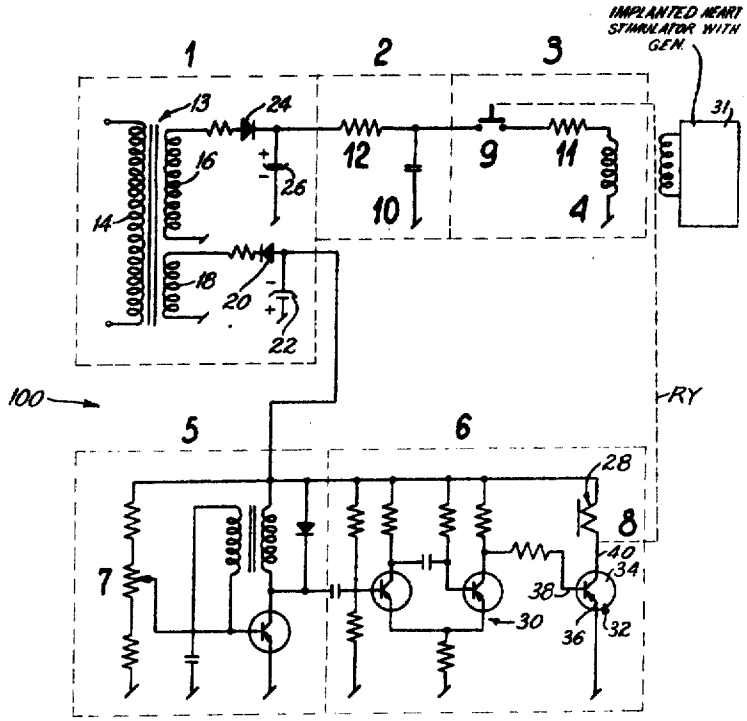
Primary Examiner—William E. Kamm

Attorney—Hubbell, Cohen & Stiefel

[57] **ABSTRACT**

An external rhythm frequency generator is magnetically coupled to a constant rhythm frequency generator of an implanted heart stimulator through an induction coil to provide either externally synchronized pulse pair stimulation or acceleration of the stimulator dependent on the frequency of a signal from the external generator. A relay is provided to control the flow of energy through the coil. A capacitive charging network is provided which discharges through the coil to create an electromagnetic field when the relay is operated. The relay is operated by a triggering circuit, which, in turn, operates the relay in synchronization with the emission of the signal from the external generator.

8 Claims, 2 Drawing Figures



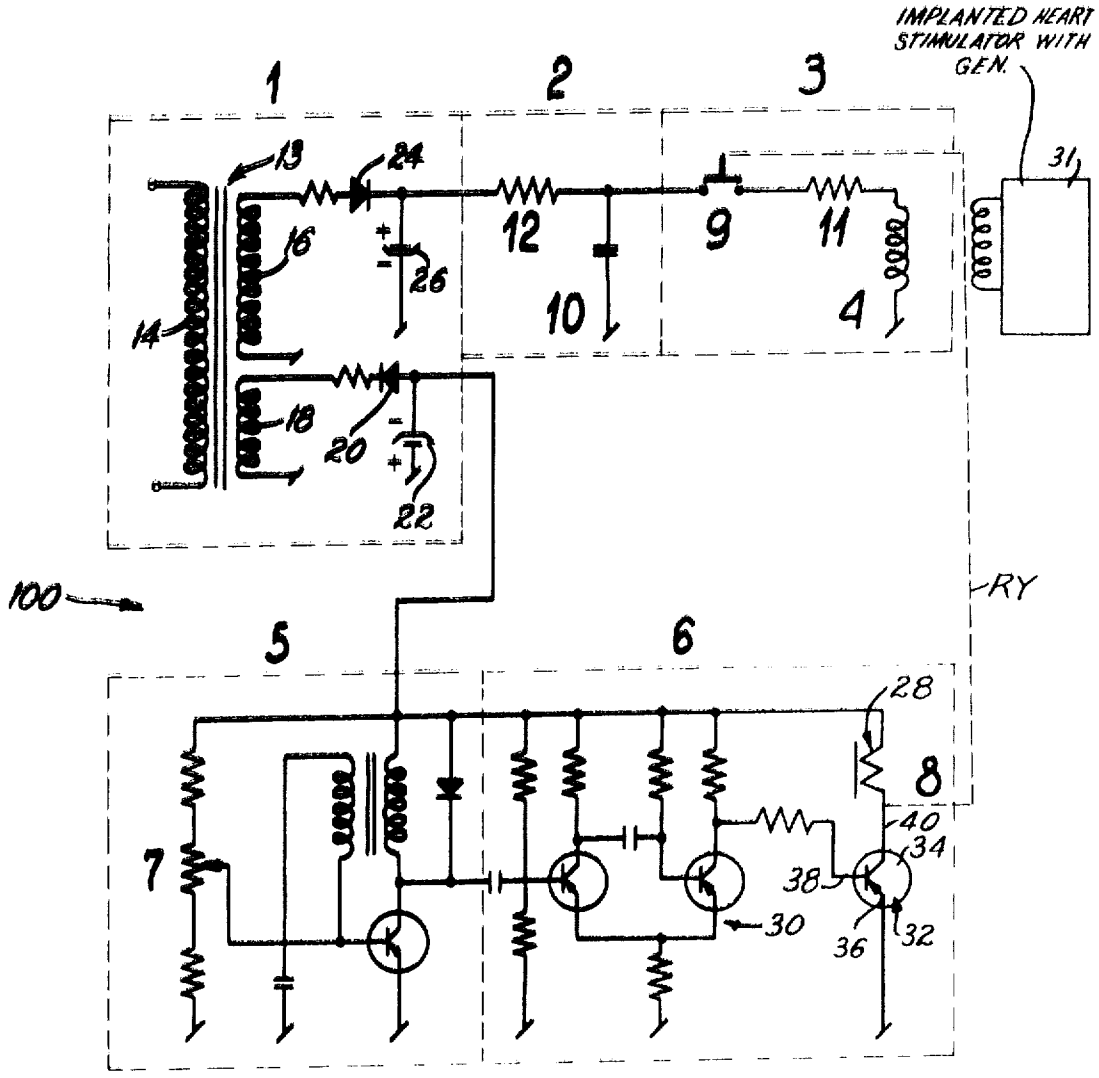

IMPLANTED HEART STIMULATOR WITH GEN.
1
2
3
13
24
16
26
12
9
11
31
14
10
4
18
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22
100
RY
5
6
28
8
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40
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32

Fig. 1

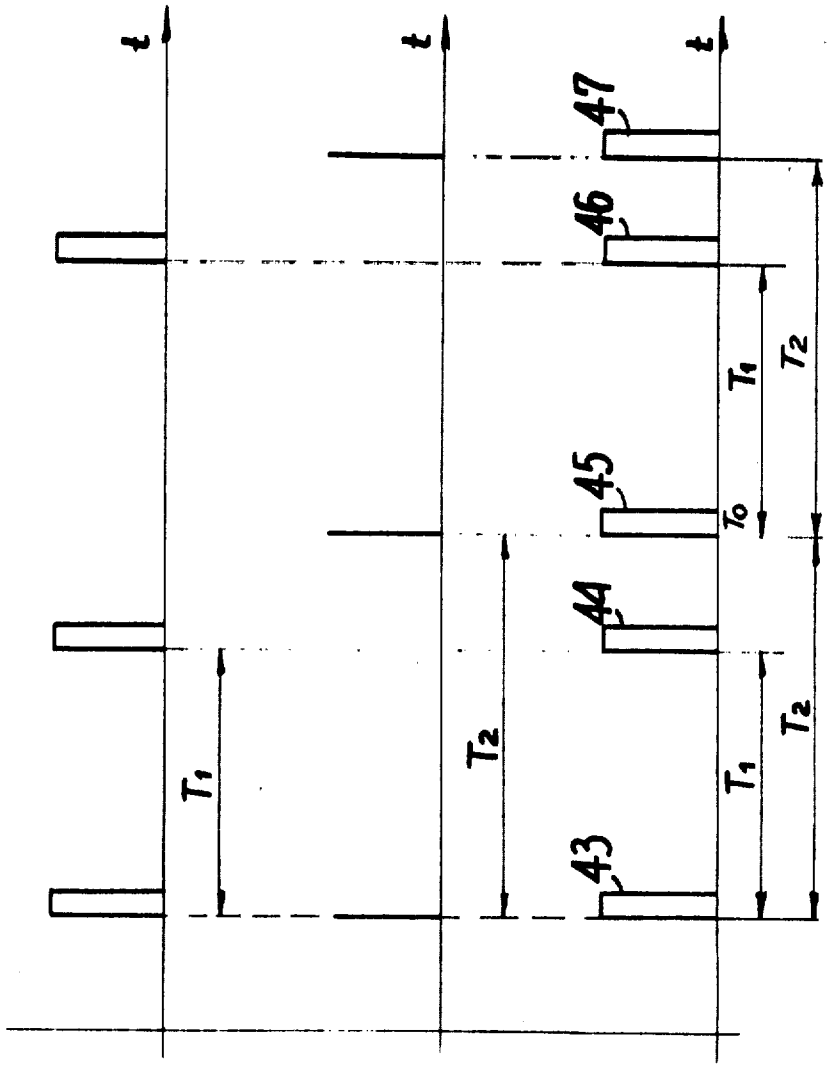


Fig. 2

METHOD OF SYNCHRONIZATION AND STIMULATION BY MEANS OF PULSE PAIRS AT IMPLANTED HEART STIMULATORS WITH CONSTANT RHYTHM AND THE CIRCUIT FOR IMPLEMENTATION OF THIS METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method and apparatus for providing stimulation from an implanted heart stimulator having constant rhythm in synchronization with the emissions of a rhythm frequency generator located outside of a patient's body.

2. Description of the Prior Art

Up to now a frequency change of triggering pulses from an implanted stimulator, or cardiac Pacemaker, having constant rhythm is accomplished by providing the stimulator with a two position relay built in the circuit of the rhythm frequency generator of the stimulator. The relay is controlled from outside of the body of the patient by applying a magnet above the place of implantation of the stimulator.

This method enables a choice of only one of two triggering frequencies established in advance for the given stimulator type. A stepless frequency change of triggering pulses is obtained up to now only in an implanted stimulator provided with a control element led outside its housing. This element is controlled by an instrument being introduced under x-ray control into the stimulator after the puncture of the skin after anaesthesia and disinfection.

In a stimulator having a constant rhythm which has no additional control elements, a stepless frequency change of pulse triggering cannot be obtained.

In stimulators having a constant rhythm, clinical complications, such as an interference of stimulator pulses with a rudimentary or natural rhythm of the heart of a patient, occur. In such cases the constancy of stimulation frequency and impossibility of its changing to adapt it to the actual electric activity of the heart is a defect which is dangerous to the life of the patient.

The method of heart stimulation with pulse pairs is the only method of electrocardiotherapy which influences not only the heart rhythm but also its mechanics of heart systole. Due to the influence upon mechanical coupling, pulse pair stimulation makes it possible to increase the force of the heart systole and at the same time the slowing of its rhythm.

Pulse pair stimulation is normally utilized after reanimation, for circulatory inefficiency, cardiogenic shocks and after cardio-surgical operations. Up to now the heart stimulation is induced by means of pulse pairs with appliances located outside the patient. The implanted heart stimulators known up to now are not capable of inducing stimulation by means of pulse pairs.

The present invention overcomes these disadvantages of the prior art.

SUMMARY OF THE INVENTION

A circuit is provided which enables external synchronization of the triggering of stimulating pulses and a stimulation by pulse pairs from an implanted heart stimulator having a constant rhythm frequency generator. An induction coil is magnetically coupled to the stimulator generator. The coil is connected in the circuit which includes a capacitive charging network. The circuit is only completed when a relay is operated. An external rhythm frequency generator is connected to a Schmitt trigger which in turn operates the relay when a signal is emitted by the external generator. When the circuit is completed, the charging network discharges through the coil which thereby generates an electromagnetic field. This field enforces the generation of a signal from the stimulator. This signal is in synchronization with the emitted external signal and provides either pulse pair stimulation if the frequency of the external signal is lower than that of the stimulator, or acceleration of the stimulator if the external signal frequency is higher.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic diagram of the preferred embodiment of the present invention; and

FIG. 2 is a graphical illustration exemplary of the operation of the embodiment shown in FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings in detail, and especially to FIG. 1 thereof. As shown and preferred, the circuit of the present invention, generally referred to by the reference numeral 100, includes a supply circuit 1. The supply circuit 1, preferably includes a power transformer 13 having a primary 14, and a pair of secondary windings 16 and 18. Secondary winding 18 is preferably connected at one end thereof to a diode 20 whose output is connected to an electrolytic capacitor 22 to provide a conventional low-voltage power supply. Similarly, secondary winding 16 is preferably connected at one end thereof to a diode 24 whose output is connected to an electrolytic capacitor 26 to provide another conventional power supply. The supply apparatus 1 power supply 16–24–26 is preferably connected to a capacitive charging network 2 to supply power thereto. The capacitive charging network 2, preferably includes a resistor-capacitor combination of a resistor 12 and a capacitor 10. The charging network 2 is in turn connected to an electromagnetic field power generator 3. The electromagnetic field power generator 3 preferably includes a resistor 11, an induction coil 4 and an armature portion 9 of a relay 8. The relay 8 also includes a solenoid 28 connected in another portion of the circuit 100 as described in greater detail hereinafter. Preferably, the relay 8 acts as a switch to open and close the circuit to the coil 4 and discharge capacitor 10 therethrough in a manner to be described in greater detail hereinafter. The induction coil 4, is preferably located outside the patient's body above the place where the heart stimulator 31 is implanted, so as to be magnetically coupled to the constant rhythm frequency generator of the stimulator 31 to enforce the generation of pulses therefrom.

The supply apparatus 1 low-voltage power supply 18–20–22 is connected to a rhythm frequency generator circuit 5. As shown and preferred, the rhythm frequency generator 5 is a conventional blocking oscillator configuration 5, and will not be explained in greater detail hereinafter. Suffice it to say, the operating frequency of the oscillator, or rhythm frequency generator 5 is controlled by means of potentiometer 7. The output of the rhythm frequency generator 5 is preferably connected to a triggering network 6. The triggering network 6 preferably includes a conventional Schmitt trigger configuration 30 connected to the generator 5 output and an output stage 32 connected to the output to the Schmitt trigger configuration 30. As shown and preferred, the output stage 32 includes a transistor 34 having an emitter 36, a base 38 and a collector 40. The solenoid portion 28 of the relay 8, whose armature portion 9 forms parts of the electromagnetic field power generator 3 as was previously mentioned, is connected to the collector 40 of the transistor 34 to receive a signal therefrom and actuate the relay 8.

OPERATION

Now the operation of the circuit 100 will be described. When the rhythm frequency generator 5 emits a signal, this signal controls the triggering unit 6 and causes the output transistor 34 to conduct, thereby providing a signal to the solenoid 28 of relay 8. This causes the operation of the relay 8. The operation of the relay 8 causes the closing of contacts 9 which completes the circuit to the electromagnetic field power generator 3. This causes the capacitor 10 of the capacitive charging network 2 to discharge through the circuit of the power electromagnetic field generator 3.

The discharge current of the capacitor 10, flows through coil 4 which causes the generation of an electromagnetic field from the coil 4. This field acts upon the circuit of the magneti-

cally coupled rhythm frequency generator of the implanted stimulator and thus enforces the generation by the stimulator of a stimulating pulse, in synchronization with the emission of the signal from the rhythm frequency generator 5.

At an operating frequency of the rhythm frequency generator 5 higher than the set frequency of the implanted stimulator a synchronic acceleration of the operation of the stimulator 31 is provided.

On the other hand, at an operating frequency of the rhythm frequency generator 5 lower than the set pulse frequency of the implanted stimulator a stimulation by pulse pairs is provided.

Referring now to FIG. 2, we shall describe an illustrative example of the operation of the circuit 100 of the present invention. Assuming the fixed rhythm frequency of the stimulator to be represented by a time interval between pulses of T1 as shown in FIG. 2, a pulse 43 is enforced by the circuit in accordance with the present invention. After the time T1 the implanted stimulator generates its own pulse 44. After the time T2, which represents the period of the rhythm frequency generator 5 as counted similarly as the time T1 from the beginning of the pulse 43, a pulse 45 is again enforced. Then the stimulator generates its own pulse 46 and the circuit, in accordance with the present invention, enforces a pulse 47.

As a result, we obtain pairs of stimulating pulses with a repeating frequency equalling the established frequency of the operation of the implanted stimulator and the time interval between the pulses of the pair equalling the difference of times T1 and T2. Time T2 changes with the change of the period of the rhythm frequency generator 5. Through the controlled change of time T2 the interval between the pulses of the pair is controlled.

It is evident that the invention is not limited only to the embodiment described in detail and represented in the drawing, but it comprises also the synchronizing of the operation of the implanted stimulators, whose rhythm frequency is controlled by the electric action of the chambers or vestibules of the heart.

What is claimed is:

1. A method for providing external synchronization of an additional heart stimulation from an implanted heart stimulator having a constant rhythm frequency generator which normally provides heart stimulations at a predetermined constant rhythm frequency, said stimulator generator having a predetermined period between said normally provided stimulations, said method comprising the steps of:

generating an independent external signal at a desired rhythm control frequency which is less than the constant rhythm frequency of the stimulator generator, the period of said external signal being greater than the period of said stimulator generator;

providing an electromagnetic field from said external signal in synchronization with said signal; and

enforcing a generation of said additional stimulation from said generator in accordance with the provision of said electromagnetic field whereby pulse pair stimulation is provided.

2. A method in accordance with claim 1, wherein said enforcing step includes the step of magnetically coupling said stimulator generator within said electromagnetic field.

3. An apparatus for providing external synchronization of an additional heart stimulation from an implanted heart stimulator having a constant rhythm frequency generator which normally provides heart stimulations at a predetermined constant rhythm frequency, the period between said normally provided stimulations being constant, said apparatus comprising:

means for generating an independent external signal at a desired rhythm control frequency which is less than the predetermined constant rhythm frequency, the period of said external signal being greater than the period of said stimulator generator, and

means for providing an electromagnetic field from said external signal in synchronization with said signal, said providing means being magnetically coupled to said stimulator generator, said stimulation being enforced from said stimulator generator in accordance with said provided field whereby pulse pair stimulation is provided.

4. An apparatus in accordance with claim 3, wherein said providing means includes means for storing a signal charge, means for discharging said storage means operatively connected to said storage means, electromagnetic means operatively connected to said discharge means and magnetically coupled to said stimulator generator, said discharge means discharging said storage means through said electromagnetic means in synchronization with the generation of said external signal, whereby said field is provided.

5. An apparatus in accordance with claim 4 wherein said providing means further includes means for triggering the discharge of said storage means by said discharge means in synchronization with the generation of said external signal, said triggering means being operatively connected between said discharge means and said generation means.

6. An apparatus in accordance with claim 4, wherein said electromagnetic means includes an inductive impedance and a resistive impedance.

7. An apparatus in accordance with claim 3, wherein said generation means is a blocking oscillator.

8. An apparatus in accordance with claim 3, wherein said storage means is a capacitive charging network including a capacitive impedance and a resistive impedance.

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